Sewage Works Journal

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Sewage Works

SOLIDS REMOVAL AS INFLUENCED BY PLANT DESIGN *

By Thomas M. Riddick and Herbert O. Johnson

Consulting Engineer and Chemist, New York City, and Superintendent, Belgrave Sewer District, Great Neck, Long Island, N. Y., Respectively

Whenever operating results of sewage treatment plants are considered, the old adage "Figures don't lie but liars figure" should be constantly borne in mind. And when a point is to be proved by analytical data, Shakespeare's admonition that "The devil can cite Scripture for his purpose" is too often appropriate.

Before operating efficiency can be correlated with plant design and before an attempt is made to compare the operation of one plant with another, it is necessary to review critically the criteria for judging plant performance, as well as the methods for collecting operating data.

Sampling Procedures

To say that a plant is operating either "well" or "poorly," because the per cent reduction of suspended solids was 66 or 46, or 86, is absolutely meaningless unless the sampling procedure, theoretical detention period, suspended solids in the raw sewage, and percentage of infiltration are also considered; and, generally speaking, they seldom are. Composite samples collected on a regular schedule may vary as much as 50 per cent throughout the year; and by selecting "appropriate sampling hours," per cent reduction on any given day may be as high as 90, or to the contrary, an actual increase of more than 100 per cent may be found.

Figure 1 shows the variation of suspended solids in the influent and effluent of the primary treatment plant of the Belgrave Sewer District over a 24-hr. period. Four-hr. samples were composited at 30-min. intervals on a basis of flow—that is, if the flow was 1.5 m.g.d., the size of sample was 150 ml.; if 0.7 m.g.d., the size of sample was 70 ml., etc.

This procedure gives a weighted composite and should present a much truer picture than collecting, say, 500 ml. at predetermined time intervals regardless of the rate of flow.

The first seeming misplacement of plotted points is the period from midnight to 6 A.M. During this interval the suspended solids of the raw sewage were considerably lower than those of the plant effluent. This, then, is a period of increase rather than a period of decrease in suspended solids, and we venture to say that it occurs in the majority of primary treatment plants. The reasons for this anomaly are not difficult to ascertain. The flow at that time consists mainly of infiltration of clear ground water, and velocities in many lines are so low that sedimentation of sewage occurs.

Actually, many plants could be bypassed (with chlorination, of course) to good advantage from midnight to 6 A.M. Not only would the effluent be lower in suspended solids than now obtains, thereby reducing the load on the receiving watercourse, but this 6-hr. rest period for the clarifiers would permit a dropping out of most of the settle-

* Presented at 18th Annual Meeting, New York State Sewage Works Association, New York City on January 18, 1946.

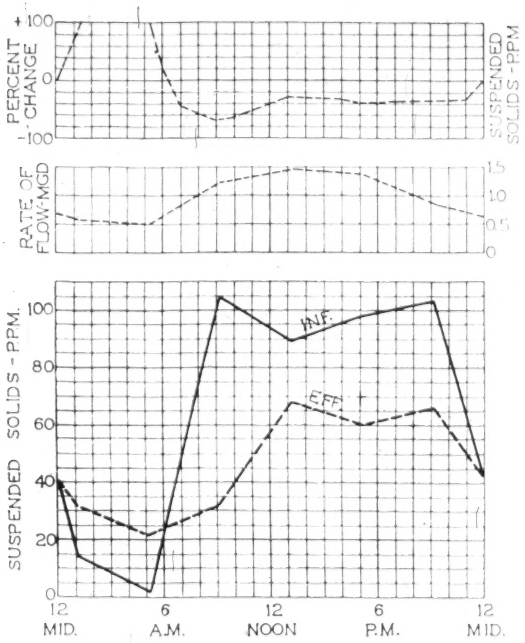

FIGURE 1.—Suspended solids removal by primary sedimentation at the Belgrave (N. Y.) Sewer District Plant.

able solids they contain. Any superintendent who has observed the plant influent and effluent at 3 A.M. knows this, and State Health Department officials, are aware of it too. Human nature being prone to take the course of least resistance, a State permit to by-pass from 12 midnight to 6 A.M. would likely result in the ultimate by-passing of many plants from 5:30 P.M. when the day shift goes off, till 8 A.M. when it returns. And so this idea must still be disregarded, although it has many interesting and attractive aspects from the standpoint of reduced watercourse loadings, as well as savings in power costs to those plants requiring continuous pumping.

There is another implication in this section of the curves. If the suspended solids of the raw sewage average only 10 p.p.m. from midnight to 6 A.M., why is it that the minimum value for the plant effluent was in excess of 20 p.p.m.? The answer must be short-circuiting alone, and this condition is quite evident if we check flowing-through periods with dyes such as fluorescein. In tanks with theoretical detentions of 2 hr., the dye is often evident in about ¼ this time and then tails out some 4 to 6 hr. later.

Aside from installing comminutors and mechanical agitators to aid agglomeration, the only way that an engineer can insure the best possible effluent from primary treatment plants is to design clarifiers so as to minimize short-circuiting. He cannot change the character of the sewage, and in regions where ground water is normally close to the surface, infiltration will gener-

ally be high unless careful and effective attempts are made to secure tight sewer joints during initial construction.

The rest of the curve is typical of many plants, if any sewage curves can be so considered. From 6 A.M. to midnight, per cent reduction (plotted at top of Figure 1) varies from zero to about 70 per cent. It's too much of a case of "select an appropriate sampling period and get the results desired"—either good or bad.

Before any true comparison of plant efficiencies can be made, a uniform system of sampling is absolutely mandatory. To eliminate existing variations or to handle them uniformly, a standard sampling procedure should be established by a national committee. The writers will only express the opinion it should be approximately as follows:

Influent samples should be composited at 30-min. intervals from 9 to 11 A.M., inclusive. Five corresponding effluent samples should be taken, and the time for each collection determined by the rate of flow, to allow for the settling period. Both influent and effluent samples should be proportioned to the rate of flow. The following is a typical example:

Hour of Sampling Influent	Rate of Flow (m.g.d.)	Influent Sample (ml.)	Detention Period (hr.)	Detention Period (min.)	Time of Sampling Effluent	Rate of Flow (m.g.d.)	Effluent Sample (ml.)
9:00 A.M.	6.0	60	1	0	1:00 P.M.	8.0	80
9:30 A.M.	6.7	67	3	36	1:06 P.M.	7.8	78
10:00 A.M.	7.5	75	3	10	1:10 P.M.	7.6	76
10:30 A.M.	8.0	80	2	58	1:28 P.M.	7.4	74
11:00 A.M.	8.0	80	2	58	1:58 P.M.	7.4	74

The foregoing is not presented as a cure-all for existing sampling procedure, but unless some uniform method is adopted nationally, the "per cent reduction" is a meaningless figure, except as applied to the individual plant.

The Interstate Sanitation Commission attempts to smooth out results by continuous sampling of both influent and effluent at 30-min. intervals from 9 A.M. to 3 P.M.—13 samples. But this procedure is too time-consuming for routine practice at most plants, and it does not include any samples of sewage during the remaining 18 hr. of the day.

Operating Records

Following are a few taken at random from THIS JOURNAL:*

Estimated population served	20,400.0
Employees for plant and sewer maintenance	13.0
Number of tanks	3.0
B.O.D., raw	301.0
Suspended solids, influent	282.0
Per cent reduction	66.0

and so on to about 75 listings for the average well prepared report. This reference is not intended as criticism, for good operating reports are far too few and their contents too meager. It does raise the question, however, that we may have taken operating forms a bit too seriously when we list such items as population, number of employees, and number of tanks to the tenth part; and it is unlikely that any technician employed by any sewage treatment plant or commercial laboratory can, in routine work, determine either B.O.D. or suspended solids to the nearest 3 to 5 p.p.m. much less to the tenth.

On duplicate samples of raw sewage, variations in suspended solids of 10 and even 20 p.p.m. are not uncommon when the time interval between desiccation and weighing is in excess of 3

* These data, taken from "Interesting Extracts from Operation Reports" in the September, 1945, issue, are not actually typical of reporting practice. Publication of some of the figures as listed was due to an editorial oversight, but the point made by the authors is well taken.—*Editor.*

min. If samples are weighted within 15 to 30 sec. after desiccation, and this is possible only when using a chainomatic balance with magnetic damper, the gain in weight due to absorption of moisture during the following 3 to 5 min. will amount to more than 5 p.p.m. when computing on a basis of 100 ml. of sample, or double this value if only 50 ml. is used. Here again is a serious matter for a national committee to decide.

There is also another observation which is timely. Of the many items listed concerning the operation of primary treatment plants, which are, of course, essential to a complete report, only two are indicative of the efficiency of the treatment process or the quality of the effluent. These are suspended solids and B.O.D.; all others indicate how readily or how economically the plant operates. The removal of grit or the transfer and digestion of sludge are but remotely related to the quality of the effluent.

With activated sludge or other types of secondary treatment, the plant operator may, by his diligence (or lack of it) produce an effluent either good, bad, or fair. But in primary treatment, when flows are within the limits of design, the operator cannot effect much change to better the quality of the effluent.

Measures of Plant Efficiency

The existing criteria for all types of sewage treatment are generally per cent removals of suspended solids and B.O.D. The reason for this is that these values are easy to compute, and to date, few better criteria have been developed or adopted. Doman's sedimentation index [*This Journal*, **17**, 3 (January, 1945)] is a step in the right direction, however, since it also takes into account the concentration of solids in the effluent as well as the per cent removal.

The Interstate Sanitation Commission requires all plants discharging into tidal waters, to treat sewage so as . . . "to remove all floating solids and at least 60 per cent (60%) of the suspended solids. . . ." Reference to this specification is made simply to substantiate the statement that per cent removal is generally accepted, even by governing boards, as the criterion for treatment.

The true distinction between plant operating efficiency and the maximum allowable pollutional loading of the receiving water course, has not been sufficiently emphasized.

Federal, state and interstate authorities should be primarily concerned with the total organic load introduced into a watercourse at any given point. This is a function of the quantity of sewage discharged daily, and the organic content. The total flow is generally measured to a high degree of accuracy. The organic content can be approximated by the suspended solids and B.O.D. determinations, but a comparable degree of exactness may be obtained only by compositing weighted samples over a 24-hr. period. When this procedure is employed, results may be converted to the much more significant values of pounds of organic matter, or pounds of oxygen demand, per 24 hr. This method also reveals that most primary treatment plants operate on a per cent removal of suspended solids of much nearer 30 than 60, the generally accepted criterion of good efficiency.

Operating efficiency, on the other hand, is simply a measure of how well the plant functions. The strength of the effluent is mainly dependent upon:

1. The strength of the influent.
2. The detention, or more properly, the flowing-through period.
3. The degree of short-circuiting through the settling basins.
4. The settleability of the sewage.
5. The volume and quality of supernatant overflow from digesters, which is returned to the plant influent, etc.

The true measure of efficiency for primary treatment plants is the percentage or amount of *settleable* solids removed, and this is quite different from removal of total suspended solids.

Operating Results

It is of interest to examine some typical operating data to determine what relations exist between detention periods and suspended solids in the plant influent and effluent. Figures 2, 3 and 4 and Tables 1, 2, 3 and 4 show data collected over a period of one year by Mr. Joseph Doman, Sanitary Engineer of the Department of Public Works, from four primary treatment plants located at Greenwich, Conn. His excellent paper, together with these primary data, was published in the January, 1945, issue of THIS JOURNAL under the title of "A Modified Index for Sedimentation Efficiency." These results were re-used since a uniform procedure was employed in collecting and analyzing samples, the laboratory analyses were precise, and the test periods covered a full operating year during which there were varying amounts of infiltration. Hourly influent composites,

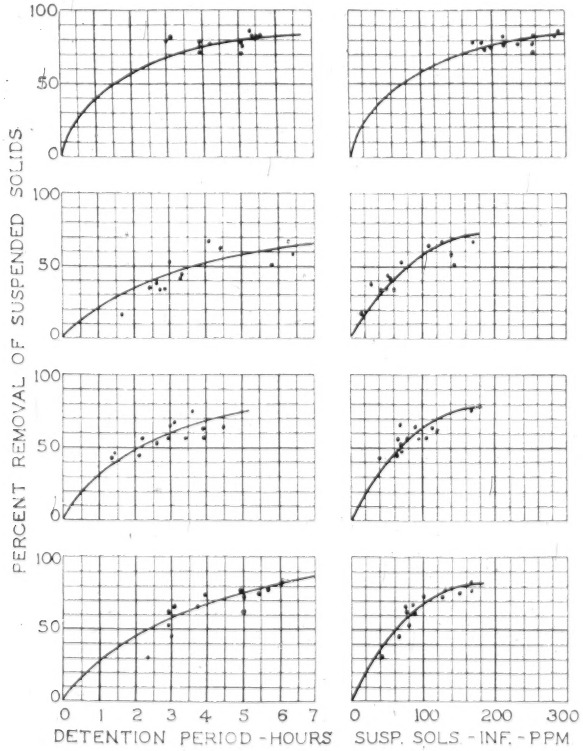

FIGURE 2.—Per cent removal of suspended solids plotted as a function of detention period and of raw sewage suspended solids.

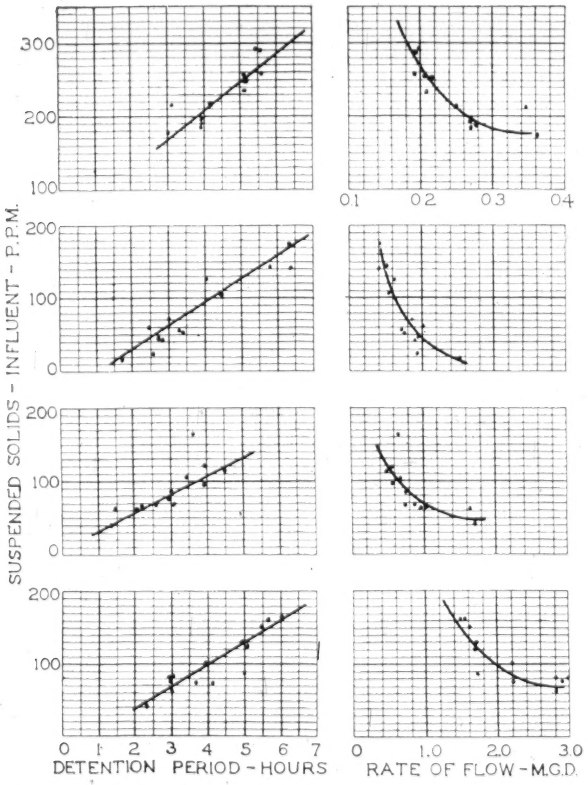

FIGURE 3.—Influent suspended solids plotted as a function of detention period and rate of flow.

collected for 5-day periods and preserved with chloroform, were taken from 8 A.M. to 2 P.M. with effluent samples composited from 10 A.M. to 4 P.M. This gives a lag of 2 hr. which is the detention period at the designed rate of flow, although this was considerably less than computed detentions since all settling basins now operate under their designed capacities.

The four plants are designated by Nos. 1 to 4. In the figures, data relating to plant No. 1 are plotted at the bottom with the curves representing the other plants placed above in numerical order. Designations are as follows:

Plant No.	Location	Designed Capacity (m.g.d.)
1	Grass Island	4.4
2	Old Greenwich	1.1
3	Cos Cob	1.3
4	East Port Chester	0.5

Figure 2 shows per cent removal of suspended solids plotted as a function of both detention period in hours (at left) and suspended solids content of the raw sewage (at right). These

curves fit the plotted points fairly well and there is good correlation between per cent removal of either suspended solids in the plant influent or settling period in hours. If samples were collected to meet a 60 per cent removal requirement (see curves at right) they would have to be taken at times when the raw suspended solids were above 80 p.p.m. for plant No. 1, 90 p.p.m. for plant No. 2, 110 p.p.m. for plant No. 3 and about 110 p.p.m. for plant No. 4. If suspended solids in the influent were below these critical values, and many were, due to infiltration during the sampling period, then no compliance was possible.

The following table was prepared by applying the per cent removal criterion. Since these are routine composite samples collected from 8 A.M. to 4 P.M., they simply represent the *yearly* variations in suspended solids.

The table shows that almost any per cent removal of suspended solids can be obtained simply by collecting samples during periods when suspended solids in the raw sewage are

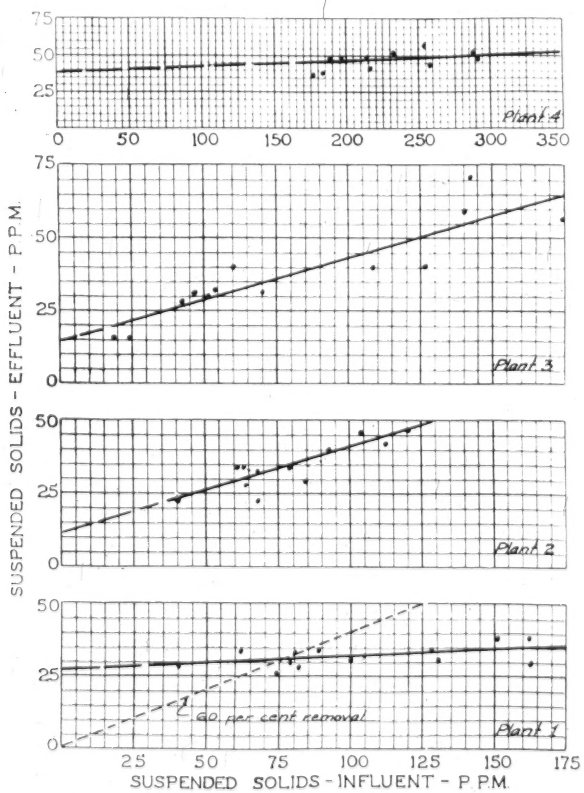

FIGURE 4.—Relation between influent and effluent suspended solids content for four primary treatment plants at Greenwich, Connecticut.

TABLE 1.—Actual and Computed Sedimentation Results Grass Island Plant, Greenwich, Conn.

Sampling Periods (1943)	Settling Period (hr.)	Suspended Solids				
		Influent (p.p.m.) (x)	Effluent (p.p.m.)	Per Cent Removal	Computed P.P.M. in Effluent* (y)	Variation Between Observed and Computed (+p.p.m.)
1/18 – 1/23	2.9	80	38	52	31	−7
2/15 – 2/20	3.0	62	34	45	30	−4
3/15 – 3/20	2.3	40	28	30	29	+1
4/12 – 4/17	5.0	88	34	61	31	−3
5/10 – 5/15	3.9	100	26	74	32	+6
6/7 – 6/12	2.9	78	30	62	31	+1
7/5 – 7/10	4.9	130	31	76	33	+2
8/2 – 8/7	5.4	151	38	75	35	+3
8/30 – 9/4	6.0	162	30	82	35	+5
9/27 – 10/2	5.7	162	38	77	35	−3
10/25 – 10/30	3.0	81	28	65	31	+3
11/22 – 11/27	3.7	74	26	65	31	+5
12/20 – 12/24	5.0	128	34	73	33	−1
Average	4.1	103	32	69	32	0
Maximum	6.0	162	38	82	35	−3
Minimum	2.3	40	26	30	29	+3

* $y = 27 + 0.05x$

TABLE 2. Actual and Computed Sedimentation Results Old Greenwich Plant, Greenwich, Conn.

Sampling Periods (1943)	Settling Period (hr.)	Suspended Solids				
		Influent (p.p.m.) (x)	Effluent (p.p.m.)	Per Cent Removal	Computed P.P.M. in Effluent* (y)	Variation Between Observed and Computed (+p.p.m.)
1/18 – 1/23	3.0	84	29	65	36	+7
2/15 – 2/20	2.1	61	34	44	29	−5
3/15 – 3/20	1.3	40	23	42	23	0
4/12 – 4/17	2.9	79	34	57	35	+1
5/10 – 5/15	3.1	68	22	68	31	+11
6/7 – 6/12	2.2	64	28	56	30	+2
7/5 – 7/10†	3.6	167	41	75		
8/2 – 8/7	3.9	120	47	61	47	0
8/30 – 9/4	4.5	113	42	63	45	+3
9/27–10/2	3.4	104	46	56	42	−4
10/25–10/30	1.4	63	34	46	30	−4
11/22–11/27	2.6	68	33	52	31	−2
12/20–12/24	3.9	93	40	57	39	−1
Average	2.9	87	35	60	35	0
Maximum	4.5	167	47	75	47	0
Minimum	1.3	40	22	42	23	+1

* $y = 11 + 0.30x$ † These values not plotted on Figure 4.

TABLE 3.—Actual and Computed Sedimentation Results—Cos Cob Plant, Greenwich, Conn.

Sampling Periods (1943)	Settling Period (hr.)	Suspended Solids				
		Influent (p.p.m.) (x)	Effluent (p.p.m.)	Per Cent Removal	Computed P.P.M. in Effluent* (y)	Variation Between Observed and Computed (±p.p.m.)
1/18– 1/23	2.8	42	28	33	26	−2
2/15– 2/20	2.7	46	31	33	27	−4
3/15– 3/20	1.7	18	15	17	19	+4
4/12– 4/17	3.3	54	32	41	30	−2
5/10– 5/15	3.3	52	30	42	29	−1
6/7 – 6/12	2.6	24	15	38	19	+4
7/5 – 7/10	4.4	108	40	63	45	+5
8/2 – 8/7	5.8	142	71	50	55	−16
8/30– 9/4	6.4	110	59	58	55	−4
9/27–10/2	6.3	174	56	68	64	+8
10/25–10/30	2.4	60	40	33	32	−8
11/22–11/27	3.0	70	32	54	34	+2
12/20–12/24	4.1	126	10	68	50	+10
Average	3.8	81	38	53	37	−1
Maximum	6.4	174	71	68	64	−7
Minimum	1.7	18	15	17	19	+4

* $y = 11 + 0.29x$

TABLE 4. Actual and Computed Sedimentation Results—East Port Chester Plant, Greenwich, Conn.

Sampling Periods (1943)	Settling Period (hr.)	Suspended Solids				
		Influent (p.p.m.) (x)	Effluent (p.p.m.)	Per Cent Removal	Computed P.P.M. in Effluent* (y)	Variation Between Observed and Computed (±p.p.m.)
1/18– 1/23	3.9	182	38	79	45	+7
2/15– 2/20	3.9	195	18	75	45	−3
3/15– 3/20	3.1	216	40	82	46	+6
4/12– 4/17†	5.1	255	76	70		
5/10– 5/15	5.6	257	44	83	47	+3
6/7 – 6/12	3.9	188	48	74	45	−3
7/5 – 7/10	5.1	254	58	77	47	−11
8/2 – 8/7	5.3	394	46	88	50	+4
8/30– 9/4	5.4	290	47	84	48	+1
9/27–10/2	5.5	289	50	83	48	−2
10/25–10/30	3.0	176	36	80	45	+9
11/22–11/27	4.2	214	48	78	46	−2
12/20–12/24	5.1	232	41	78	46	−5
Average	4.5	242	49	80	52	+3
Maximum	5.6	394	76	88	54	−12
Minimum	3.0	176	36	70	46	+10

* $y = 39 + 0.04x$

† These values not plotted on Figure 4.

Plant Number	Raw Suspended Solids (p.p.m.) Required for Indicated Percentages of Removal				
	40	50	60	70	80
1	40	60	80	110	150
2	50	70	90	120	180
3	60	80	110	180	—
4	—	—	110	150	230

high, and it will be later shown that the concentration of solids in raw sewage depends to a very large extent upon infiltration. This finding is not new but recognition of this fact is quite belated.

At plant No. 3, for example, where there is considerable dilution of sewage through infiltration, when the suspended solids of the influent are 60 p.p.m., the per cent removal is only 40. When the raw solids increase to 80 p.p.m., per cent removal rises to 50. Sixty per cent removal is effected only when suspended solids are 110 p.p.m. or above. During periods of minimum infiltration, removal rises to 70 per cent due to an increase of raw solids to 180 p.p.m.

In spite of these great variations in per cent removal and notwithstanding the fact that the majority of samples collected from this plant showed a per cent reduction well under 60, the effluent was still reasonably good, averaging only 38 p.p.m., and a minimum value as low as 15 p.p.m. suspended solids was obtained.

It seems therefore that per cent removal is more a criterion of infiltration than either treatment efficiency or organic loading of the receiving watercourse.

Excellent correlation also exists between the detention period in hours (Figure 2, left) and the per cent removal of suspended solids. Here again, if the 60 per cent limit is to be met, flows must be such that detention periods equal or exceed 3.2 hr. for plant No. 1; 3.0 hr. for plant No. 2; 5.5 hr. for plant No. 3, and about 2.3 hr. for plant No. 4. These curves represent detention periods at given plants with *given population loadings;* they are *not* curves to show increase in per cent removal as a function of the detention period.

The reason that the per cent suspended solids removal is a definite function of the raw suspended solids content is readily apparent upon examination of the data from which these curves were made. If I represents the suspended solids in p.p.m. in the influent and E the suspended solids in the effluent, then the per cent removal equals $I - E/I \times 100$ and this then is plotted as a function of I. Since values of I are considerably greater than those for E, and values of E are fairly constant, then plotted points cannot deviate far from a curve of this type.

If per cent reduction depends upon the solids content of the raw sewage, then it seems unfair to rate a plant as "below standard" simply because the sewage was dilute at the time of sampling. The strength of sewage at any given plant is greatly influenced by the amount of infiltration, and this in turn depends upon rainfall, the elevation and location of the sewer lines, and the variations in ground water levels. In separate sewer systems, infiltration is readily manifest by fluctuation in minimum or night flows as well as the variation in total flow from wet to dry seasons.

Is plant No. 4, which shows a constant reduction in suspended solids of over 70 per cent, doing a much better job than plants Nos. 1, 2, or 3, where the per cent reduction in the majority of samples was below 60? And will the effluent from plant No. 4 be less innocuous to the receiving watercourse than those of the other three? It seems not, for if a new sewer extension with high infiltration is connected to plant No. 4, the suspended solids content of the raw sewage must drop through dilution; and with that, down drops per cent removal. Even under

existing conditions the suspended solids content of the effluent from plant No. 4 averaged 49 p.p.m. as against 32, 35 and 38 p.p.m., respectively, for plants Nos. 1, 2 and 3, hence plant No. 4 must also give the greatest loading of organic matter to the watercourse per million gallons of effluent.

The popular "per cent reduction" figure may be convenient to use—but it is even easier to abuse, and it can be extremely misleading when applied to a few individual samples.

The curves at the left in Figure 3 show another interesting relationship between suspended solids in the weekly composite of the raw sewage samples and detention period in hours. This correlation is excellent and for any given set of plants operating with a constant population loading, the greater the settling time the greater the strength of the sewage, or *vice versa*. This relation may not be readily apparent; it becomes understood, however, when we consider the facts, for the greater the infiltration the greater the flow, and the greater the flow the less the detention, as well as the concentration of suspended solids.

Here again it is noted that all samples were collected on a regular schedule and represent variations in settling time due only to yearly variations in sewage flow. These data are in no way related to the variations in suspended solids and hours of detention throughout any single operating day. The plotted values are precisely the same as those shown at the right in Figure 3, except that here is plotted raw suspended solids as a function of rate of flow. Although these curves are hyperbolas and are not so easily extended, they present a more readily comprehensive picture of the relationship. Note in the bottom curve at right that the concentration of suspended solids at 1.5 m.g.d. is about 150 p.p.m. This then, is dry weather flow. When the rate is doubled to 3.0 m.g.d., such increase *must* be due to infiltration or storm water, and the suspended solids are actually about halved to 70 p.p.m. This same relationship holds sufficiently true for all of these curves to enable the preparation of the following table:

Plant Number	Minimum or Dry Weather Flow (m.g.d.)	Suspended Solids (p.p.m.)	
		At Dry Weather Flow	At Double Dry Weather Flow
1	1.5	150	70
2	0.5	120	65
3	0.4	170	70
4	0.2	270	170

Since doubling the flow causes a drop in suspended solids of about 50 per cent, *any excess over these minimum yearly flow values must be due principally to infiltration*, which is a point too lightly stressed in most published work and is usually overlooked in the interpretation of analytical data.

These curves show another interesting relationship, which can likewise be presented in tabular form as follows:

Plant Number	Minimum or Dry Weather Flow (m.g.d.)	Maximum or Wet Weather Flow (m.g.d.)	Suspended Solids (p.p.m.)		Max./Min. Ratio	
			Maximum	Minimum	Flow	Suspended Solids
1	1.5	3.8	150	50	2.5	3.0
2	0.5	1.7	120	50	3.3	2.4
3	0.4	1.5	170	20	3.8	8.5
4	0.2	0.36	270	170	1.8	1.6

The correlation between the ratios of maximum to minimum flows and suspended solids provides further proof

that the concentration of suspended solids in the raw sewage is to a large extent a function of the amount of infiltration or storm water entering the system. Where the concentration of suspended solids varies widely through the year, the infiltration is quite large. Where the amount of infiltration is relatively low, as in the curve for plant No. 4, the solids content likewise shows slight variation and the concentration of solids in the raw sewage is high.

Figure 3 (left) shows that when the concentration of solids in a clarifier is highest, the detention period is the greatest. One effect more or less counterbalances the other, so that at any given plant the effluent does not show much fluctuation in suspended solids throughout the year, whether the sewage be "strong" in the dry season or "weak" during wet months.

Another set of significant curves is shown in Figure 4. These take into account all of the variables heretofore listed, although they are simple plots of suspended solids in the effluent as a function of the strength of raw sewage. The location of each curve was determined by the method of least squares. In form these are straight lines, originating at *points above* the intersections of the horizontal and vertical axes. The general equation for this type of curve is:

$$y = a + bx$$

where y = p.p.m. suspended solids in effluent,
x = p.p.m. suspended solids in influent,
a = a constant (in p.p.m.) readily determined for any plant.

These curves fit the data quite well. The deviation was not greater than 5 p.p.m. for 75 per cent of the 52 points plotted, and a deviation of ± 5 p.p.m. is not at all inconsistent with analytical and sampling procedures. The equations for these curves are as follows:

Plant No.	Equation of Curve
1	$y = 27 + 0.05\,x$
2	$y = 11 + 0.30\,x$
3	$y = 14 + 0.29\,x$
4	$y = 39 + 0.04\,x$

We may express these equations in a more understandable way by employing terms normally used in evaluating results of sewage treatment plant operation. Values of a (27, 11, 14, 39) simply represent the minimum suspended solids possible for these particular plant effluents. These minima depend upon two factors only: one is the settleability of the sewage in question which the engineer designing the plant cannot change; the other is the flowing-through period, which is affected to a very appreciable extent by the degree of short-circuiting through the sedimentation basins, and this can be reduced by careful design. If there were long-time records of non-settleable solids (determined by siphoning off the upper third of a sample of raw sewage which has stood for 24 hr. at relatively constant temperature), it would be possible to better evaluate these plants from the standpoint of clarifier efficiency. Unfortunately these tests are not run as routine at Greenwich, or at many other plants.

Values of b in the equation $y = a + bx$ are simply the tangent of the slope of the curve, or the per cent of settleable suspended solids remaining in the effluent. Mathematically this is 100 per cent less the per cent removal of suspended solids.

The elements of these equations can be expressed in tabular form as follows:

Plant No.	Min. Possible Susp. Solids in Plant Effluent (p.p.m.)	Raw Settleable Solids Remaining in Effluent (%)	Reduction of Raw Settleable Solids (%)
1	27	5	95
2	11	30	70
3	14	29	71
4	39	4	96

The per cent reduction of raw settleable solids is somewhat a misnomer since the "minimum suspended solids in the plant effluent" shown in the table must necessarily be higher than the true non-settleable solids, due to short-circuiting.

In Figure 4 (bottom) a dashed line of 60 per cent reduction of suspended solids is shown. Does the curve coincide with plotted data for plant No. 1, or for plants 2, 3 and 4? Definitely no, since the curve starts at the intersection of the x and y axes, thereby totally ignoring non-settleable solids as well as the effects of short-circuiting. It definitely imposes an unwarranted penalty on plants with weak sewage, while giving an undeserved reward to plants having a raw sewage high in suspended solids.

Table 1 shows operating data at the Grass Island plant. Probable values for the effluent are shown, computed by means of the equation $y = 27 + 0.04x$. Although per cent removal of total suspended solids varied widely from 30 to 82, probable values for the effluent based on the formula deviated from analytical results by a maximum of only 7 p.p.m. and eight of the 13 computed values deviated by no more than 3 p.p.m. The ability of this plant to reduce suspended solids is therefore definitely expressed more accurately by the formula than by percentage removal. Similar comparison of computed and observed results for the other plants is made in Tables 2, 3 and 4.

These and other data presented herewith lead to the following conclusions regarding criteria for evaluating sedimentation tank operation:

1. From the standpoint of organic loading of the receiving watercourse, which after all is the reason for the existence of sewage treatment plants, the criterion should be the total pounds of organic matter or oxygen demand introduced per day. This can only be determined by the suspended solids and B.O.D. content of the sewage effluent, and in spite of the many difficulties inherent thereto, 24-hr. sampling seems mandatory unless a factor is determined to convert samples collected in shorter periods into these terms.

2. Plant performance, on the other hand, should be based on per cent removal of settleable suspended solids, and *not* on per cent removal of total suspended solids.

Design Applications

The statement has previously been made that the only way an engineer can better the effluent of a primary treatment plant is to design sedimentation basins so as to reduce short-circuiting. What are these ways? At the Belgrave sewage treatment plant the following remedial measures were incorporated into the design and, although sufficient analytical data have not been compiled to prove this point, the clarity of the effluent from the sedimentation basins as judged visually, indicates that these measures were highly effective:

1. Influent flumes were tapered proportionally to flow so as to maintain a velocity of 1.0 ft. per sec. at all inlet ports. This resulted in uniform distribution of sewage at the entrance end and effectively prevented precipitation of sludge in the inlet chamber.

2. A flocculator was added for agglomeration as well as to smooth out the daily differentials in temperature and suspended solids.

3. The sedimentation basin was roofed over with a concrete slab on which was placed a 4 ft. earth cover to prevent short-circuiting through thermal overturns, which occur during settling.

4. Effluent weirs were made easily adjustable and of sufficient length to prevent high heads during peak flows.

5. The tank was designed as shallow, narrow and long as space, sub-grade

and economic limits of design would permit.

These may seem to be simple expedients but their importance cannot be underestimated when it is realized that they represent the only ways in which engineering design can influence the quality of the effluent.

Summary

In summary, this paper has attempted to demonstrate logically that:

1. The "per cent reduction" figure, without adequate qualifying data, is almost always misleading when used in comparing the operating efficiencies of sedimentation units.

2. Practice in both sampling and analytical procedures for suspended solids is badly in need of revamping on a national scale.

3. The raw suspended solids content of any sewage is largely dependent upon the percentage of storm water and infiltration.

4. Both settleable and non-settleable solids must be determined before operating efficiency can be properly evaluated.

5. At any plant where adequate analytical data covering a period of one year are available, the suspended solids of the effluent can be predicted with reasonable accuracy from the suspended solids content of the influent by means of the equation $y = a + bx$. In rating plant efficiencies and in establishing standards of performance it seems reasonable to require that primary treatment plant effluents should not exceed a certain fixed sum (representing p.p.m. non-settleable solids) plus a given percentage of the raw suspended solids.

No attempt has been made to suggest standards of plant performance but the writers are hopeful that this work will be followed up by others, to the end that evaluation of operation data will be more completely rationalized.

SEWAGE OXIDATION PONDS—PERFORMANCE, OPERATION AND DESIGN

By D. H. Caldwell

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Sewage oxidation ponds as used in southwestern United States may be described as shallow artificial basins designed to receive clarified sewage continuously for a nominal detention period of from 3 to 4 weeks and to provide a maximum photosynthetic action. Losses from percolation and evaporation are normally negligible in comparison to inflow.

It is the purpose of this paper to discuss sewage oxidation ponds by presenting (1) performance data gathered during the past three years from municipal, army and navy installations in California, Nevada and Arizona, (2) operating details and (3) design features.

History of Use in Southwestern States

Mr. C. G. Gillespie, Chief, Bureau of Sanitary Engineering, California State Department of Health, a pioneer in this field, discussing this subject before the Arizona Water and Sewage Association at Phoenix, Arizona, in 1942, aptly described the status of this method of sewage treatment in the following:

"That oxidation ponds are not more used can be explained by their crudity compared to neat engineering structures, the unattractive green coloration of the effluent and perhaps by the fact that too few engineers are aware of the potentialities for oxidation of organic matter. Properly laid out for size and embodying a few simple details, oxidation ponds absorb and destroy the odors of sewage, leaving nothing worse than the smell of a swamp. The effluents are permanently stable with B.O.D. values as good or better than those of trickling filter effluents. As a destroyer of sewage bacteria, they possess almost unbelievable efficacy. Final overflow from ponds designed for 15 days detention will show 5–50 *B. coli* per cc. compared to something like 100,000 per cc. in the original sewage. Such results continue day after day and therefore will rank with, or outrank, the results from chlorination in reliability."

In California the sewage purification powers of oxidation ponds were first discovered accidentally at Santa Rosa in 1924. These ponds were formed by the clogging of a prepared gravel seepage area.

Later that same year, the town of Vacaville, California, made application to the State Bureau of Sanitary Engineering for permission to impound septic tank effluent during the summer in order to prevent injury to private property. Partly as a result of observations at the ponds at Santa Rosa, the state granted permission and ponds were built at Vacaville. Results of effluent tests made by the state shortly thereafter indicated 7 to 15 p.p.m. of dissolved oxygen and 12 to 30 p.p.m. B.O.D. Nitrates were found and *B. coli* varied between 1 and 50 per ml.

In 1929 oxidation ponds were designed and constructed for the town of Sonoma, California, to treat a septic tank effluent. Eight acres of ponds were provided, varying in depth from 12 to 18 in. and provided with channels and gates for flexibility. Laboratory tests by the State Bureau of Sanitary Engineering again demonstrated a high degree of purification. Based on a population of 750, detention was 20 days, B.O.D. values were reduced to 20 p.p.m. and *B. coli* were reduced to less than 100 per ml. D.O. varied from 4 to 14 p.p.m. The Sonoma ponds were eventually abandoned because of overloading from industrial wastes.

Because of these favorable experi-

ences, the bureau shortly thereafter recommended the conversion of an existing sewage farm at Calistoga into an oxidation pond system. Conversion was completed and in 1930 the bureau made tests indicating consistently favorable results.

In March, 1943, A. W. Rheinhardt, Assistant Sanitary Engineer, State Bureau of Sanitary Engineering and the writer, also Assistant Engineer with the State Bureau of Sanitary Engineering, tested the action of these ponds during two 24-hr. periods. It was found that maximum D.O. varied from 12 to 20 p.p.m. in the different ponds, while the B.O.D. varied from 5 to 25 p.p.m. and *B. coli* from 2.3 to 23 per ml. During the night, D.O. disappeared from all ponds while the pH fell from 9.5 to 6.0.

Other tests made by the state indicated 25 to 35 p.p.m. D.O. in the effluent from ponds receiving clarified sewage at Imperial, California, while a maximum of 18 p.p.m. was observed during a 24-hr. study of the Modesto, California, oxidation ponds receiving a poor grade bio-filter effluent. The latter study, made by the writer, indicated a considerable reduction of total B.O.D. throughout the ponds.

At present there are about 30 plants in California where ponding of either treated or untreated sewage is practiced. Giesecke and Zeller (1) described a 14-acre lake at A&M College, Texas, used to receive sewage. A year's performance record indicates the B.O.D. of the effluent to be as low as 10 p.p.m. in winter and to reach a maximum of 80 p.p.m. in midsummer. O'Connell and Gray (2) discuss land disposal of sewage. Suggestions of design features of oxidation ponds are included. The paper also includes discussions by C. G. Gillespie and W. T. Knowlton.

Where climate is suitable, and level land is available and cheap, oxidation ponds offer an economical means of obtaining complete treatment of sewage. If designed properly, they can be expected to produce an effluent suitable for discharge without nuisance into a dry water-course throughout the year. The first cost of the oxidation ponds, exclusive of primary treatment facilities, may range from $0.50 to $3.00 per capita, depending on the size of the ponds and the cost of the land, larger ponds being cheaper on a per capita basis.

Because the oxygen-producing capacity of algae is greatest in summer due to long, warm days, the ability of oxidation ponds to absorb and destroy sewage organic matter is greatest in these months. Thus, the possibility of using oxidation ponds to augment other sewage treatment processes, which become inadequate due to heavy seasonal loads from canneries and other industries operated only during summer months, should not be overlooked. For these conditions, the tentative capacity factors given later in this paper can be materially increased, perhaps even doubled.

The ability of oxidation ponds to produce an effluent of comparatively high bacterial purity can be utilized by providing ponds with several days storage capacity following other complete treatment units such as trickling or high-rate filters, activated sludge units, or intermittent sand filters. By this arrangement also, temporary upsets in plant operation and sudden heavy loads can be absorbed in the oxidation ponds before the effluent is ultimately discharged.

Performance

General

The performance of any sewage treatment plant should be measured and judged by its ability to produce an effluent which meets local requirements and, in addition, the sewage treatment plant itself should be free from objectionable odors, especially if located near human habitations. Tests which are suitable for measuring the efficiency

of one type of plant may not be suitable for another.

Nearly all of the commonly accepted sewage tests have been tried in an effort to find a measure of the efficiency of sewage oxidation ponds. The two most used criteria for quality of effluent, the B.O.D. test and the suspended solids test, are of little value, when considered alone, in measuring the quality of the effluent from sewage oxidation ponds. This is because of the presence of large numbers of algal cells which increase the B.O.D. and suspended solids but which do not produce obnoxious conditions below the outfall as does an equivalent concentration of organic matter of sewage origin.

Nevertheless, the common sewage tests, when considered together with other tests, some of which have been developed especially for sewage oxidation ponds, give a fairly accurate picture of the actual conditions which prevail. For example, the results of the B.O.D. test of oxidation pond effluent will be found to vary from 10 p.p.m. in the winter to as much as 100 p.p.m. in the summer and yet we know that the stability of the effluent, as measured by the nitrogen determination, is actually greater in summer than in winter.

In order to understand the inter-relation between the various possible tests which can be applied to oxidation pond effluent, an attempt will be made to describe briefly what happens to the sewage as it passes through an oxidation pond. The tests will then be listed and each in turn will be discussed in the light of the fundamental changes taking place in the pond.

As the clarified sewage enters the oxidation pond, it is teeming with bacteria, most of which prefer aerobic conditions. Dissolved oxygen may or may not be present in the influent, depending upon the age of the sewage as it enters the plant and upon the type of preliminary treatment employed. In either case, the sewage is mixed immediately with oxygen-containing water creating a favorable environment for aerobic oxidation.

During the destruction of the sewage organic matter by aerobic bacteria, algae* grow abundantly in the presence of sunlight. Life processes of algae are the reverse of those of bacteria. Algae can utilize water and carbon dioxide with traces of potassium, nitrogen, and phosphorus, and in the presence of sunlight, produce starch. The quantity of organic matter appearing in the form of algal cells may at times exceed the amount originally present in the sewage. Furthermore, dead algal cells, undergoing decomposition by bacteria, may exhibit a high B.O.D. and under certain conditions may deplete the dissolved oxygen in receiving streams. Their destruction, even in these abnormal instances, however, seems never to cause objectionable odors. Thus, while the total organic matter in an oxidation pond effluent may be appreciable as measured by the B.O.D. test, it will be found that very little, if any, of the original sewage organic matter remains.

It appears from the results of bacteriological tests of many oxidation ponds that the coliform-type bacteria are destroyed rapidly in the presence of algae. While the exact mechanism of this destruction is not known, it is believed to be due to the liberation by the algae of chlorellin (3), a substance similar to penicillin in its action on bacteria. The bactericidal effect of the algae, however, does not seem to interfere with the stabilization of the sewage organic matter. The algae are also associated with various types of non-chlorophyll bearing protozoa which may serve to destroy bacteria. The net result of the action of these protozoa is similar to that of bacteria in that

* The term "algae" is used in this discussion in its broadest sense to include all chlorophyll-bearing organisms present in the plankton. Some of these organisms, such as the *Euglena* species, are commonly classified as protozoa.

both derive their energy by the breakdown of the dead organic matter present.

Analytical Interpretations

The B.O.D. test of oxidation pond effluent can be made by the standard dilution method. It is important, however, to incubate the samples in the dark, since in the presence of light, algal metabolism through photosynthesis will liberate oxygen. The correlation of B.O.D. results with other observations indicates that the B.O.D. of an oxidation pond effluent is composed of two parts. One part is due to dead organic matter and includes original sewage organic matter as well as dead algal cells. The other part is due to algal cells which were alive at the time of sample collection but which die during the 5-day B.O.D. incubation period. Experimental and routine tests of effluents from ponds in central California indicate that the B.O.D. due to sewage organic matter may reach 10 to 20 p.p.m. in winter and may approach zero during summer.

Suspended solids in oxidation pond effluents follow somewhat the same variations as does the B.O.D., *i.e.*, a minimum in winter and a maximum in summer when algal metabolism is at its highest rate.

Perhaps the most important test, and at the same time the most difficult to evaluate, is some sort of odor determination which will give an overall picture of the operation of the sewage treatment plant. Odors in sewage are usually associated with septicity or lack of oxygen. Sewage containing even a trace of dissolved oxygen is not offensive and does not produce hydrogen sulfide. Odor surveys can be made, but they are time-consuming and generally serve to focus attention on the sewage treatment plant. Thus, tests which indicate potential odors are important. In an oxidation pond where algae are growing in sufficient quantity to impart a green coloration to the water, dissolved oxygen will be present and offensive odors absent. Thus, dissolved oxygen or color of the ponds is important in evaluating their odor-producing capacity. When dissolved oxygen is absent, hydrogen sulfide may be produced. It has been the experience at various plants employing oxidation ponds in California that odors will be noticed at considerable distance from the ponds when the total sulfide content exceeds 2 p.p.m. This, of course, depends somewhat on the pH of the pond water but is a fair average. Another visual observation which is very interesting and also instructive is the appearance of the surface. As a result of faulty design or operation, septic areas may be formed. These are readily distinguished by the degree of wave action as the result of wind (Figure 1). The septic areas are always smooth and glassy, whereas the other areas are characterized by normal wave action.

Pond effluents normally contain some nitrate. In summer the ammonia may disappear entirely from the pond effluent due to bacterial oxidation and use by certain forms of algae. Algal metabolism during summer may remove carbon dioxide at a sufficiently high rate to cause the pH to rise. Values as high as 10.5 have been found in slightly buffered waters during hot sunny days. Values of 9.5 are common even in highly buffered waters (400 p.p.m. $CaCO_3$). The phenolphthalein alkalinity correlates perfectly with algal activity and furnishes an excellent record thereof. An increase in dissolved oxygen usually accompanies high pH values. Oxygen concentrations of 35 p.p.m. or 400 per cent of atmospheric saturation have been found on occasions, while values of 10 to 20 p.p.m. are common in summer months. During the night hours the oxygen concentration and pH always decrease. The actual reductions depend upon total alkalinity. In the case of low alkalinity waters, the oxygen

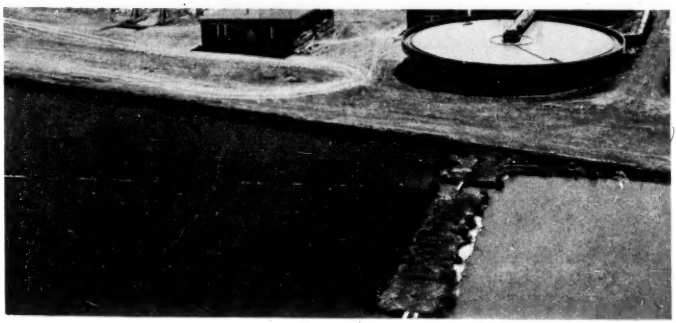


FIGURE 1.—Illustration of effect of septicity on wave action in oxidation ponds. Note lack of waves in septic pond at right.

content has been observed to fall from 300 per cent saturation to zero.

Large concentrations of algae produce greenish turbidity which may be noticeable for considerable distances below the outfall. Live algal cells can be destroyed by chlorination with approximately 10 p.p.m. chlorine and removed by allowing the effluent to settle several hours before discharge into the receiving stream.

Oxidation Ponds at U. S. Naval Station, Shoemaker, Calif.

Sewage treatment at the U. S. Naval Station, Shoemaker, California, consists of primary clarification with separate sludge digestion, treatment of clarifier effluent in oxidation ponds 100 acres in area and chlorination of pond effluent (if necessary) with final disposal into Laguna Creek, thence into Alameda Creek. The system is shown in plan in Figure 2, and pictorially in Figure 3. A map of the vicinity indicating the course of the disposal streams and the location of sampling stations is shown in Figure 4.

Operation of the sewage works is under the direct supervision of the Public Works Officer attached to the station. Operating advice and design

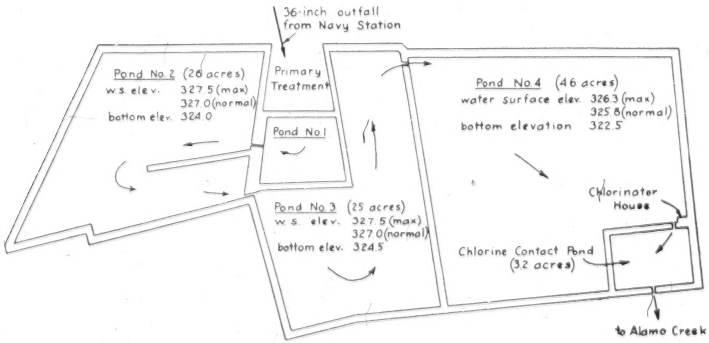


FIGURE 2.—Plot plan of sewage oxidation ponds, U. S. Naval Station, Shoemaker, California.

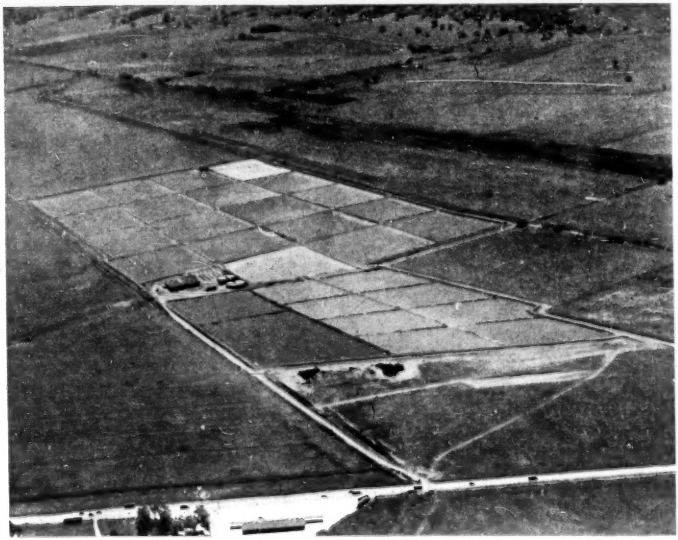


FIGURE 3.—Aerial photograph of sewage treatment plant, U. S. Naval Station, Shoemaker, California.

service are furnished by the Twelfth Naval District Public Works Department and by the Superintending Civil Engineer, Area VI, Bureau of Yards and Docks, Navy Department. Sanitary engineers are stationed at these activities.

The plant was designed for the Navy by W. D. Peugh and Associates of San Francisco, with Messrs. C. E. Bentley and Charles H. Lee acting as consultants to the engineers. Charles Gilman Hyde, consulting engineer, reviewed the recommendations for the Navy and concurred in the general features of the original proposal.

Complete records of the operation of this sewage treatment plant have been kept since June, 1944. Because of the number and frequency of tests, all results except those having to do with sludge digestion have been summarized by months and plotted on graphs for the period from August, 1944, to August, 1945. All graphs are shown in Figure 5. Observations and tests are divided into two groups. In one group are included all tests made in the field by the operating personnel, all Naval enlisted men. The operators were instructed in making the tests by sanitary engineers attached to the District Public Works Department of the Twelfth Naval District. The second group of tests includes all determinations made at the Twelfth Naval District Sanitary Engineering Laboratory under the direction of sanitary engineers. Tests were made on 24-hr. composite samples collected at 8-day intervals so that a fair picture of changes occurring throughout the week was obtained. The following sampling stations were selected:

(a) Raw sewage—sampled from lift-pump discharge.
(b) Primary effluent—sampled at

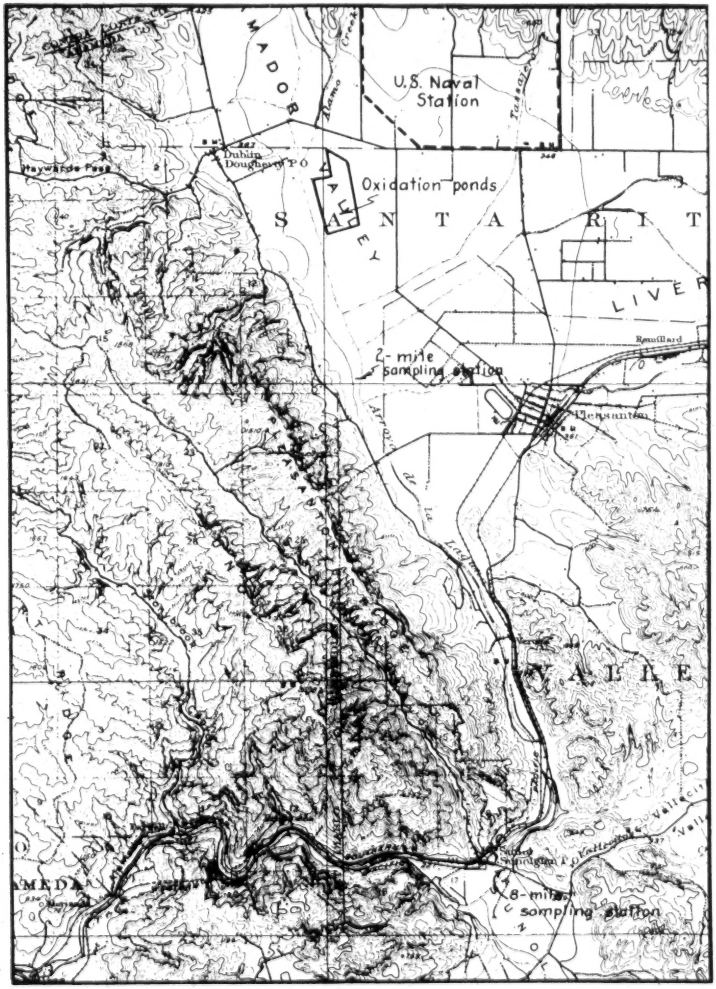


FIGURE 4.—Map showing location of sampling stations along Laguna Creek, U. S. Naval Station, Shoemaker, California.

division box as sewage entered the first pond.

(c) Final effluent—sampled at effluent weir.

(d) 2-mile sample—taken from Laguna Creek approximately 2 miles below outfall.

(e) 8-mile sample—taken from Laguna Creek approximately 8 miles below outfall.

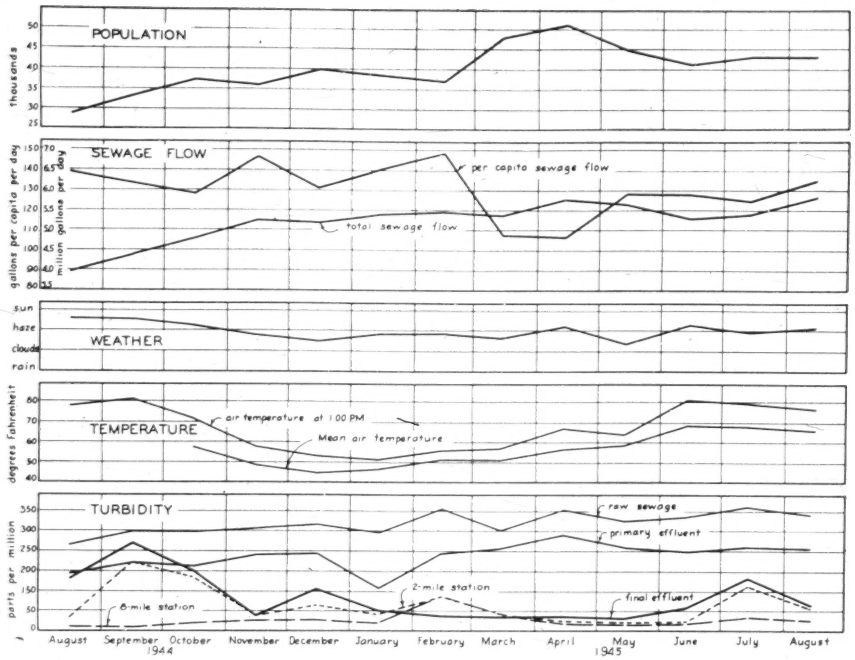


FIGURE 5.—Graphical summary of analytical and operating data, U. S. Naval Station, Shoemaker, California.

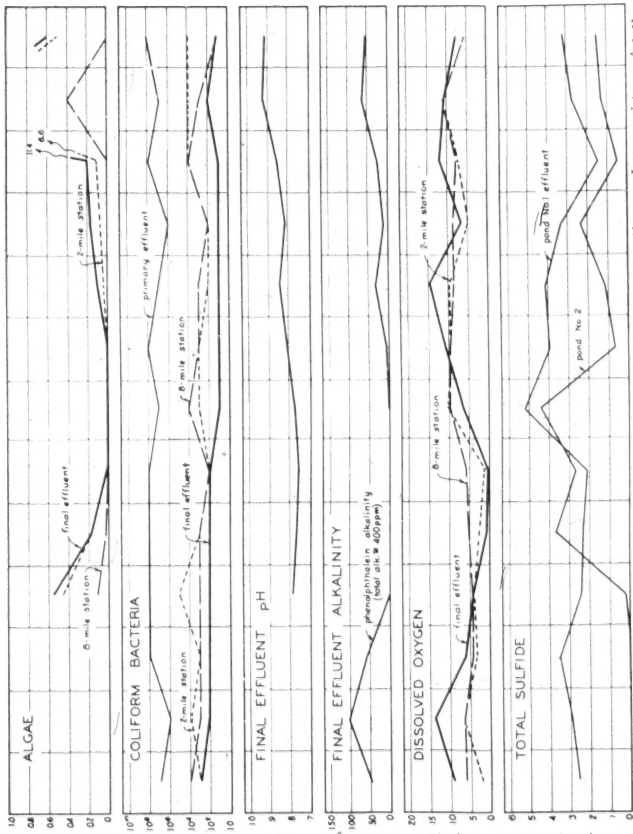


FIGURE 5.—Continued.

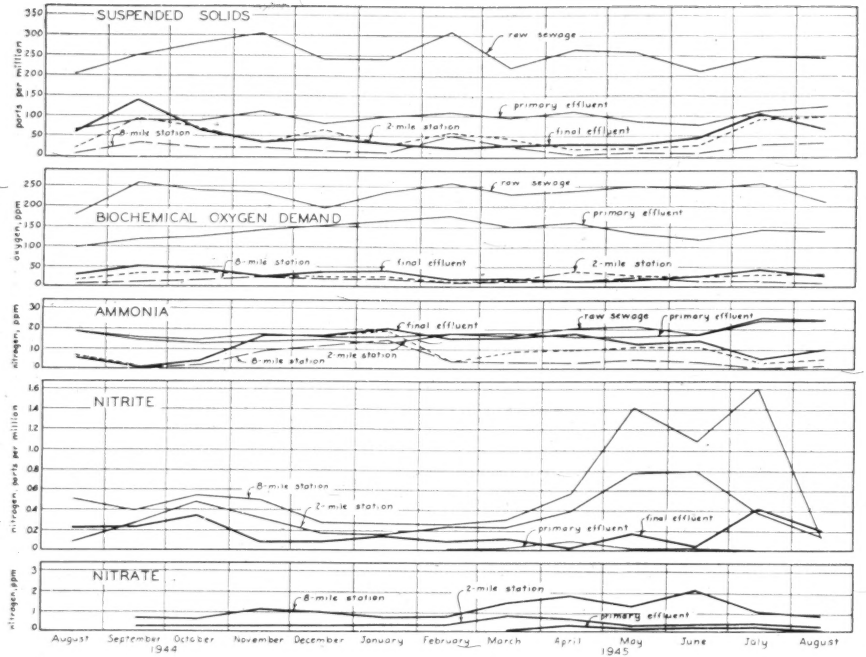


FIGURE 5.—Continued.

Samples from the latter two stations, which are shown on Figure 4, are spot samples collected about 1 P.M. every eight days. Each sample of raw and of primary effluent was composited from equal volumes at hourly intervals. The final sewage effluent composite was made up from four equal spot samples collected at 6-hr. intervals. All composites were refrigerated during the collection period and were analysed immediately thereafter. Samples for bacteriological analysis were collected each day. Plantings were made from 1 to 24 hr. after collection.

Descriptions of test procedures and discussions of results follow (Figure 5):

Population was obtained as a monthly average of official daily records. It does not include men on liberty or a few civilian workers. Population varied from 30 to 50 thousand during the year's period covered by the records, which represents an areal pond loading of 300 to 500 persons per acre.

Sewage flow was measured by recording the time of operation of the sewage lift pumps at the plant. Pump capacities were determined from characteristic curves and are estimated to be from 15 to 20 per cent high. No correction, however, has been made on the indicated sewage flow. The monthly average was obtained from daily measurements.

Weather. In the absence of a suitable recording light meter, the average daily weather condition was estimated by the plant operators and recorded in one of four categories as sunny, hazy, cloudy or rainy. For plotting purposes, the sunny condition was weighted arbitrarily at 3 with the other conditions as 2, 1 and 0 respectively. The monthly average was obtained from daily observations.

Air temperature was observed at 1 P.M. each day. The upper curve is the monthly average of these observations. The lower curve is the mean air temperature obtained from the weather station at the Navy headquarters.

Turbidity of the composite samples collected at 8-day intervals was measured, using a Jackson turbidimeter. It is to be observed that the turbidity of the raw and settled sewage follows somewhat the population curve. The turbidity of the effluent shows extreme fluctuations with peaks in the spring, summer and fall. This turbidity is due to algae, as consideration of the algal curves indicates.

Algae. The total volume of algae in the effluent and the downstream samples was determined in an Imhoff cone by killing the algae with formaldehyde and allowing them to settle overnight. Unfortunately, this test was not started until November, 1944, so that a complete year of record is not available. The curves indicate, however, that the samples contain considerably more algae in summer than in winter, which confirms visual observations. It is to be noted that the algae tend to disappear from the downstream samples. At no time, however, were odors noted along the disposal stream. Microscopic examinations were made several times during the year to determine the type of algae present. *Euglena*, a chlorophyll-bearing protozoan, was found to be predominant, usually in nearly pure culture. Figure 6 is a photomicrograph of the effluent from the Shoemaker ponds made in August, 1945. According to actual count, about 99 organisms out of each one hundred were found to be *Euglena*. Relatively few crustacea were present.

Coliform Bacteria. The coliform index was determined in the effluent each day and at the downstream sample stations every eight days. Analyses were made according to standard methods, using brilliant green bile for confirmation. Portions examined were as follows: two of 10 ml. and one each of 1, 0.1, 0.01 and 0.001 ml. The index was computed according to the Phelps method.

Since a monthly average of daily Phelps index values is meaningless if one value happens to be extremely high, all values for the month were arranged according to magnitude. The median value was then selected and plotted for the month. For several of the months containing an even number of days the two middle values of the array differed by a multiple of ten. In these cases the higher value was used in plotting the chart.

An examination of the chart reveals an extremely low average coliform index for the effluent. Individual samples very often would show no positive presumptive tests in any of the portions examined, in spite of the fact that at no time during the period covered by this report was any chlorine used. These results are about equal to those obtained from samples collected from clean California streams receiving no sewage. Samples containing as high as 10,000 coliform bacteria per 100 ml. were obtained on a few occasions.

The astounding efficiency of these ponds in removing coliform bacteria is believed to be due to the liberation of substances toxic to bacteria by the algae. It is known that the alga *Chlorella* produces such a substance. Investigation is now underway to isolate the active agent from the effluent. It should be noted that the high bacterial reductions cannot be attributed to high pH values.

During the month of August, 1944, experiments were conducted to determine the effect of chlorine on the algae and bacteria in the effluent. Chlorine dosages varied from 12 to 15 p.p.m. during these tests. The algae were partially killed by the chlorine and settled in the contact pond. The algae reduction was shown by a corresponding reduction in turbidity after chlorination and by a fishy odor near the point of chlorine application. Coliform bacteria, however, increased slightly as evidenced by data shown in Table 1. Chlorination was discontinued as a result of these experiments, the algae being relied upon for disinfection of effluent.

TABLE 1.—Effect of Chlorination on the Coliform Index of Oxidation Pond Effluent. U. S. Naval Station, Shoemaker, California

Date	Coliform Index (number per 100 ml.) Before Chlorination	After Chlorination
August 2, 1944	8	100
August 3, 1944	10	10
August 4, 1944	100	100
August 5, 1944	100	6
August 6, 1944	10	1000
August 7, 1944	10	1000
August 8, 1944	10	1000
August 9, 1944	100	10,000
August 10, 1944	1000	1000
August 11, 1944	10	10
August 12, 1944	10	100
August 13, 1944	100	1000
August 14, 1944	10	1000
August 15, 1944	—	100
August 16, 1944	100	10
August 17, 1944	100	1000
August 18, 1944	10	1000
August 19, 1944	10	10,000
August 20, 1944	1000	10,000
August 21, 1944	10	1000
August 22, 1944	10	—
August 23, 1944	100	10
August 24, 1944	—	1000
August 25, 1944	10	1000

Effluent pH. The pH of the effluent was determined daily at 1 P.M. using a colorimetric method. The monthly average of the daily tests is plotted on the chart. The pH of the effluent is a good indication of the rate of algal metabolism, the higher the pH the more rapid the growth. This is because algae extract dissolved carbon dioxide from water, causing a shift in the carbonate-bicarbonate equilibrium and increasing the pH in accordance with the equation:

$$pH = pK_2 + \log \frac{[CO_3^{=}]}{[HCO_3^{-}]}$$

Values of 9.6 were observed at times. Later studies made over a 24-hr. period indicate that the pH value falls off at night. The decrease depends upon the total alkalinity or buffer capacity of

the water. In these ponds, alkalinity averages about 400 p.p.m. and the pH falls only about 1.0 unit during the night. At other ponds having a lower alkalinity, pH changes of 3.0 units through the night have been observed.

Alkalinity of Effluent. Only the phenolphthalein alkalinity of the effluent has been plotted in the chart because the total alkalinity remained nearly constant at 400 p.p.m. $CaCO_3$. It is to be noted that during September, 1944, an average of 200 p.p.m. of carbonate alkalinity was transformed. This represents a CO_2 consumption by the algae of at least 3,000 lb. per day or 30 lb. per acre per day, the total pond area being 100 acres. This calculation excludes free CO_2 produced by bacterial action. Periods of high phenolphthalein alkalinity correspond with periods of high turbidity of the effluent.

Dissolved oxygen tests were made using the sodium azide modification of the Winkler procedure. Reagents were added within a few minutes after sample collection. No special apparatus was used in collecting the samples, hence the results for supersaturated samples may be slightly low.

Monthly averages were obtained from daily tests of the effluent and from tests made at 8-day intervals for the downstream samples. The average dissolved oxygen in the effluent varied from a few tenths of a part per million to 15 p.p.m. Results for individual days varied from zero to 25 p.p.m. Low values occur in the winter when algal activity is low or lacking. It is to be noted, however, that the D.O. in the disposal stream never fell below 4 p.p.m. in spite of the fact that during the greater part of the year no flow other than the plant effluent was present.

Suspended Solids and B.O.D. Suspended solids were determined by filtering the composite sample through No. 40 Whatman filter paper. B.O.D. of the composite samples was determined by the dilution method at 20°C. All samples were incubated 5 days in the dark. Both the suspended solids and B.O.D. of the raw and settled sewage are normal for this type of installation. The per capita contribution of B.O.D. varies between 0.2 and 0.25 pounds, which high values are typical of other military establishments. Suspended solids are increased during the summer by the growth of algae, which also impart a green turbidity to the water. The B.O.D. is likewise increased (if the samples are incubated in the absence of light). It is believed that in the 5 days required for the B.O.D. test, nearly all the algal cells start to decompose and therefore contribute to the B.O.D. value obtained. When algal metabolism is low, it is not uncommon to find individual B.O.D. values in the effluent of 5 to 10 p.p.m. The monthly average for the Shoemaker plant was less than 20 p.p.m. from February to May of 1945. This is typical of other oxidation ponds.

Total sulfide was measured daily at the outlet from the No. 1 pond; about half way through the No. 2 pond, and at the final outlet. Sulfide in the No. 1 and 2 ponds is not significant except for this particular plant where provision for distribution of settled sewage is inadequate.

Traces of sulfide in the effluent were noted on several days during February. The monthly average, however, was too low to plot on the chart. At all other times sulfide was absent in the effluent.

Nitrogen Tests. Ammonia, nitrite and nitrate nitrogen tests were made on the composite samples collected at 8-day intervals. Ammonia nitrogen averages 20 to 30 p.p.m. in the primary effluent while both nitrite and nitrate are generally absent. Reduction of ammonia through the ponds and in the disposal stream is maximum in the summer, less than 1 p.p.m. being found during the month of September, 1944. Accompanying the decrease in ammonia was an increase in both nitrite and nitrate. The increase in nitrite plus nitrate does not, however, account for

the nitrogen available from the decrease in ammonia which was probably used by algae. No definite correlation could be found between the nitrate and nitrite except that both appeared to increase during summer, indicating a higher degree of oxidation during these months. Total nitrogen tests were not made.

A 24-hour test of the Shoemaker ponds was made starting at 1 P.M. on August 23, 1944. Dissolved oxygen, pH and alkalinity were determined at the nine sampling stations as often as possible (approximately every 2 hr.). At each sampling station composite samples were collected in proportion to the sewage flow. The composite samples were then analyzed in the District laboratory for turbidity, color, alkalinity, suspended solids, 5-day B.O.D., ammonia, nitrite, nitrate and chloride. Several samples for bacteriological analysis were collected at most of the sampling stations. In addition, influent and effluent sewage flow and sunlight intensity were measured.

Some results of this study are shown graphically in Figures 7 and 8. Figure 7 indicates the variation in sewage flow, sunlight intensity and dissolved oxygen throughout the 24-hr. Dissolved oxygen is shown for the raw sewage and for the effluents from Nos. 2, 3 and 4 ponds. Figure 8 illustrates graphically the results of the laboratory analyses of the composite samples. All results are plotted on a common abscissa, which represents approximately the theoretical time of flow between the various sampling stations.

It is interesting to note that the quality of effluent from No. 2 pond, as measured by B.O.D. and suspended solids, was superior to that from any of the other ponds, except the chlorine contact pond. The increase in turbidity, B.O.D. and suspended solids in the latter ponds was due to the rank growth of algae. This growth, however, was accompanied by a reduction in ammonia with first an increase and then a decrease in nitrate and nitrite. After chlorination, bacteria were able to produce carbon dioxide faster than algae could use it, hence the pH de-

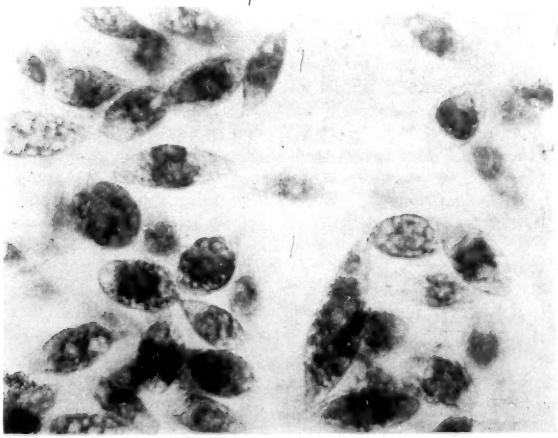


FIGURE 6.—Euglena in oxidation pond effluent, U. S. Naval Station, Shoemaker, California. Photomicrograph reproduced by courtesy of Purification Division, San Francisco Water Department.

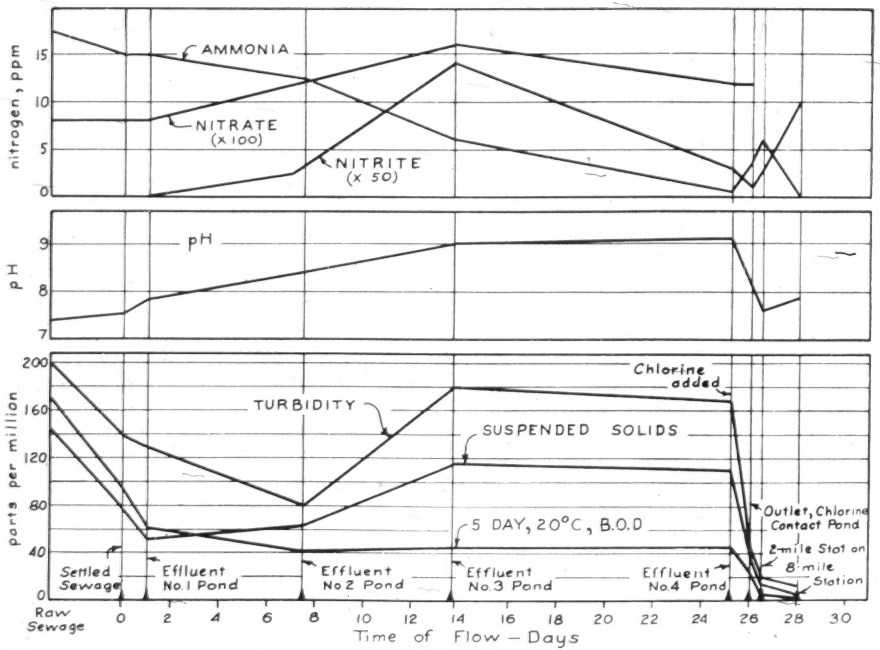


FIGURE 7.—Hourly variation in sewage flow, sunlight intensity and dissolved oxygen, U. S. Naval Station, Shoemaker, California.

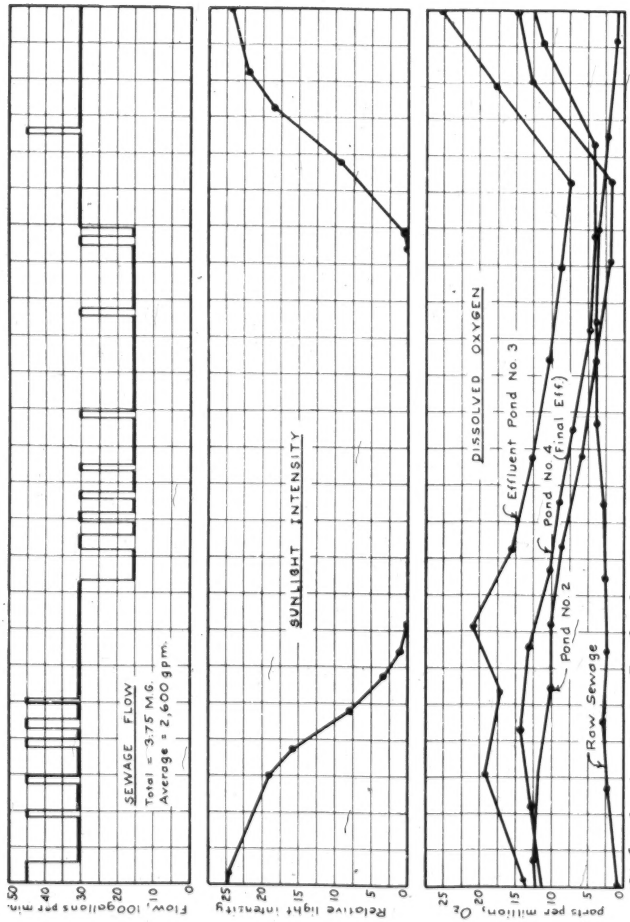

SEWAGE FLOW
Total = 3.75 M.G.
Average = 2,600 gpm.
Flow, 100 gallons per min.
SUNLIGHT INTENSITY
Relative light intensity
DISSOLVED OXYGEN
Effluent Pond No. 3
Pond No. 4 (Final Eff.)
Pond No. 2
Raw Sewage
parts per million, O2
1PM 2 3 4 5 6 7 8 9 10 11 12PM 1AM 2 3 4 5 6 7 8 9 10 11 12M
AUG. 23, 1944
AUG. 24, 1944

FIGURE 8.—Graphical summary of results of 24-hour study, August 23–24, 1944, sewage treatment plant, Shoemaker, California.

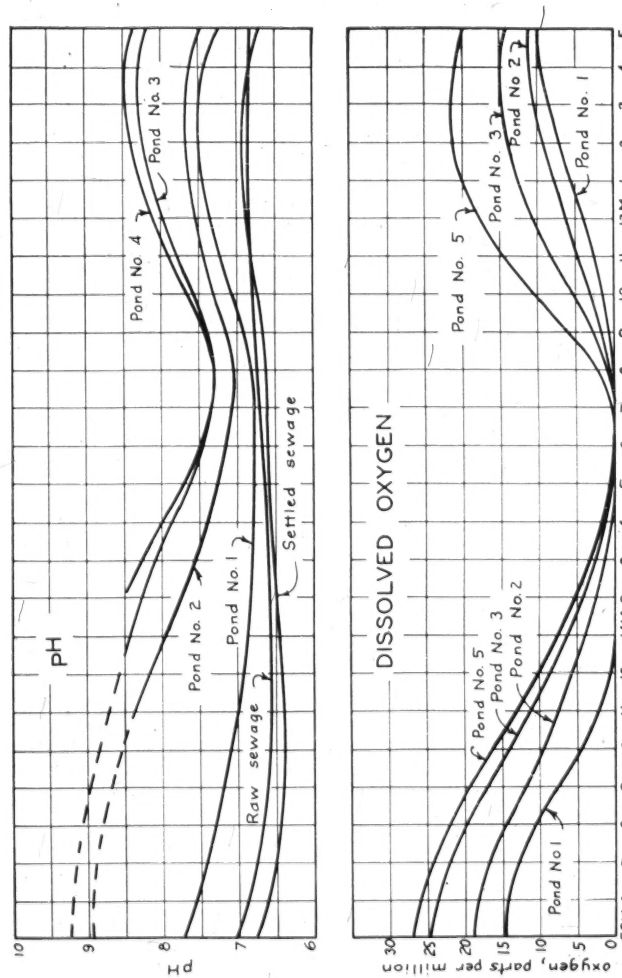


FIGURE 9.—Hourly variation in dissolved oxygen and pH, sewage oxidation ponds, Calistoga, California.

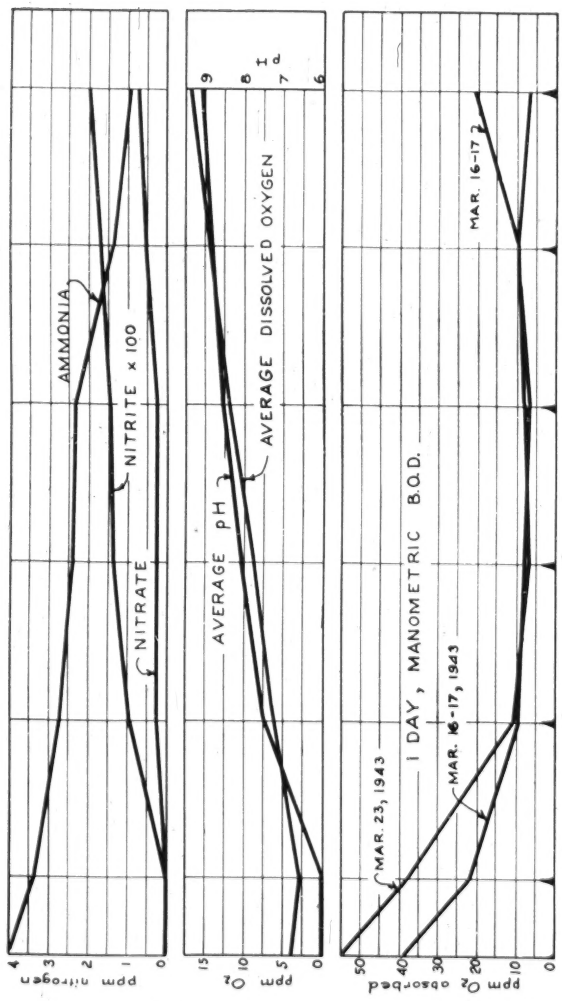


FIGURE 10.—Graphical summary of results of 24-hour study, March 16–17, 1943, sewage oxidation ponds, Calistoga, California.

creased. The reduction in algae concentration after chlorination was evidenced by the sharp reduction in turbidity, suspended solids and B.O.D. The photograph (Figure 3) made on April 16, 1944, also illustrates pictorially the growth of algae in the various ponds, rank algal growth producing a darker water surface. The ponds in the lower left corner are extremely dark with algal growth due to restricted circulation of fresh sewage. Ponds in the center of the picture and the one in the upper right corner are nearly devoid of algae. At the time this photograph was made, approximately 12 p.p.m. of chlorine was being added to the effluent at the point shown in Figure 2, thus killing all algae in the chlorine contact pond. The No. 1 pond was septic at the time this photograph was made.

Oxidation Ponds at Calistoga, California

The sewage treatment plant at Calistoga, California, consists of primary clarification followed by seven oxidation ponds in series with final disposal into Napa Creek. The primary effluent flows into three openings in the

TABLE 2. Results of Tests of Effluent from Sewage Oxidation Ponds Near Fallon, Nevada. Pond area, 8 acres; primary treatment in septic tanks; plant started May, 1944

	Date of Sampling						
	6/27/44	9/8/44	11/23/44	2/12/45	5/18/45	9/22/45	11/3/45
Pond loading (persons per acre)	200	200	200	300	300	300	300
Turbidity (p.p.m.)	430	200	150	250	180	170	170
Color	Green	Green	Green	Green	Green	Green	Green
pH	10.1	8.4	8.1	8.1	9.6	9.1	9.3
Total alkalinity as $CaCO_3$ (p.p.m.)	194	140	344	248	118	243	258
Phenolphthalein alk. (p.p.m.)		63	14	0	60		
Dissolved oxygen (p.p.m.)	15.2						7.7
Hydrogen sulfide (p.p.m.)	0						0
Suspended solids (p.p.m.)	384	170	32	53	17	85	85
5-Day B.O.D. (p.p.m.)	31	55	11	60		83	59
Ammonia N (p.p.m.)		0	3	12.5	0.6	2.0	
Nitrite N (p.p.m.)		0	0.01	0.08	0.08	0	
Nitrate N (p.p.m.)		—	0.2	0.02	0.08	0	

TABLE 3. Results of Tests of Effluent from Sewage Oxidation Ponds Near Hollister, California. Pond area, 2 acres; primary treatment in septic tanks

	Date of Sampling		
	9/13/44	11/3/44	3/8/45
Pond loading (persons per acre)	500	600	600
Turbidity (p.p.m.)	155	200	550
Color	Green	Gray green	Very green
pH	9.0		8.2
Total alkalinity as $CaCO_3$ (p.p.m.)	382	560	524
Phenolphthalein alk. (p.p.m.)	64	—	0
Dissolved oxygen (p.p.m.)	11.5	0.4	6.0
Hydrogen sulfide (p.p.m.)	0	0	0
Suspended solids (p.p.m.)	167	54	82
5-Day B.O.D. (p.p.m.)	41	81	131
Ammonia N (p.p.m.)	1	16.5	15
Nitrite N (p.p.m.)	0	0	0
Nitrate N (p.p.m.)	—	0	0

TABLE 4.—Results of Tests of Effluent from Sewage Oxidation Ponds Near Crows Landing, Calif. Pond Area, 4 acres; primary treatment in septic tanks

	Date of Sampling					
	8/4/44	9/12/44	10/12/44	12/21/44	1/25/45	3/7/45
Pond loading (persons per acre)	200	250	300	300	300	350
Turbidity (p.p.m.)	25	24	210	260	260	190
Color	Green	Yellow green	Green	Green	Green	Very green
pH	9.4	8.0	8.5	7.5	7.9	8.9
Total alkalinity as $CaCO_3$ (p.p.m.)	176	376	164	280	380	318
Phenolphthalein alk. (p.p.m.)	48	0	13	0	0	0
Dissolved oxygen (p.p.m.)	—	4.0	7.4	—	—	2.4
Hydrogen sulfide (p.p.m.)	—	0	0	—	—	0
Suspended solids (p.p.m.)	40	37	61	92	153	121
5-Day B.O.D. (p.p.m.)	25	26	40	94	77	65
Ammonia N (p.p.m.)	1.0	12.5	7.5	2.5	17.5	17.5
Nitrite N (p.p.m.)	0.1	0	0	0.03	0	0
Nitrate N (p.p.m.)	—	—	—	0	0	0

TABLE 5.—Results of Tests of Effluent from Sewage Oxidation Ponds Near Santa Rosa, Calif. Pond area, 8 acres; primary treatment in septic tanks

	Date of Sampling		
	9/22/44	12/2/44	10/23/45
Pond loading (persons per acre)	Approx. 200	500	700
Turbidity (p.p.m.)	170	160	180
Color	Yellow green	Light green	Green
pH	10.2	7.4	8.4
Total alkalinity as $CaCO_3$ (p.p.m.)	560	372	360
Phenolphthalein alk. (p.p.m.)	—	0	0
Dissolved oxygen (p.p.m.)	25.2	—	—
Hydrogen sulfide (p.p.m.)	0	—	—
Suspended solids (p.p.m.)	121	22	109
5-Day B.O.D. (p.p.m.)	53	74	70
Ammonia N (p.p.m.)	0	12.5	25
Nitrite N (p.p.m.)	0	0	0
Nitrate N (p.p.m.)	—	—	0

center of the first pond. The depth of the ponds averages about 1 ft.

Studies of these ponds were made by A. W. Reinhardt, Assistant Sanitary Engineer, Bureau of Sanitary Engineering, California State Department of Health, and the writer on March 15, 16 and 23, 1943, for the California State Bureau of Sanitary Engineering. The first study covered a 24-hr. period while the second covered only the daylight hours.

Results of these studies are presented graphically in Figures 9 and 10. A comparison of these results with those of the Shoemaker tests demonstrates the effect of alkalinity on D.O. and pH changes, which are seen to be a maximum when the alkalinity of the sewage is low as at Calistoga (120 p.p.m.).

Tests of Other Oxidation Pond Systems

Several oxidation pond sewage treatment systems in use at Naval stations have been tested at intervals through a year's operation period. These tests have been summarized and are presented in Tables 2 to 5.

Operation

The operation of properly designed oxidation ponds is extremely simple. Often nothing is required to be done for periods of several months at a time. It is wise, however, to make more frequent inspections. The following operating advice is the result of several years' observations of oxidation ponds in California.

Control of Odors

Rapid and thorough mixing of the incoming clarified sewage with the partially oxidized pond water is essential to the operation of oxidation ponds. Sewage which is allowed to collect near one end of a pond or in the first pond of a series will quickly become septic, especially in winter. Multiple inlets or frequent change of the point of inlet is necessary to prevent septicity and odors. Satisfactory design of an oxidation pond is shown in Figure 12. It is important to keep each inlet free of obstruction when multiple inlets are used such as are illustrated. In abnormal conditions such as may result from overloading, sodium nitrate has been used to combat septicity and odors (4). The nitrate thus added furnishes oxygen (in anaerobic environment only) for bacterial decomposition of organic matter and prevents the production of hydrogen sulfide. Enough sodium nitrate is added to satisfy 20 per cent of the 5 day B.O.D.

Cleaning Ponds

At intervals of 6 to 8 years, it may be necessary to remove sludge accumulations from the pond. This can be accomplished by draining half the pond area, drying and scraping the accumulated material to the banks using a bulldozer.

Control of Weeds on Banks

Earth banks should be kept free of weeds by clipping or by use of soil sterilants. Sodium arsenite applied at the rate of 2 lb. per 100 sq. ft. will eliminate all growth for 3 to 4 years (5). Existing weeds should be cut before the sodium arsenite is applied.

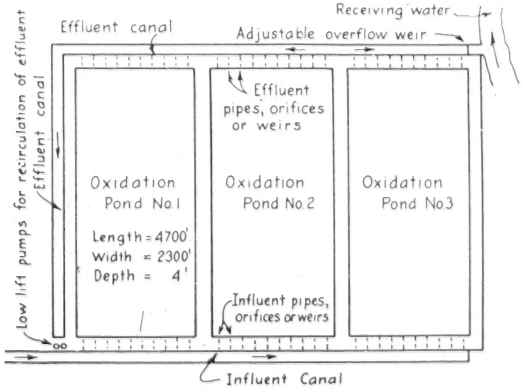


FIGURE 11.—Diagram showing suggested handling of very large oxidation pond areas where cost of diffusion piping would be excessive and its hydraulic behavior difficult to predetermine and control.

Note: Canals and levees are shown greatly exaggerated in width. With properly designed recirculating pumps, any desired ratio of pond effluent to raw settled sewage influent can be obtained, thus preventing septicity at inlet ends of ponds.

Control of Aquatic Weeds

Control of aquatic weeds of the emergent type presents a more serious problem. Only tule (*scirpus* species) and cat-tail (*typha* species) seem to cause trouble in the ponds so far observed. The depth below which these plants will not take root is not known exactly although it appears to be about 18 in. to 2 ft. If, however, a root is once started, growth will occur even though the water depth is maintained at 3 ft. Aquatic weeds therefore are not usually encountered in ponds which are kept full at all times. For conditions where either tule or cat-tail have gained a start, for one reason or another, the following procedure has been found effective in securing complete removal (6). The pond is drained and the growth is cut as near the ground as possible. The pond is then refilled to a depth of 1 ft. or sufficient to cover the ends of the cut vegetation. Benoclor is introduced just below the water surface by means of a garden-type pressure sprayer, taking care that the area is thoroughly covered. From 15 to 50 gal. of Benoclor per acre is applied in this manner. After several days, the pond is put back in service. Weeds are killed or injured by the absorption of the chemical through the leaves, stalks and cut ends. Treatment should be applied in the spring or summer and is effective for 1 to 3 years, depending upon the fertility of the soil and the amount of reseeding and upon the precautions taken to maintain the depth greater than the maximum rooting depth of the weeds.

Control of Mosquitos

Mosquito larvae are able to survive in oxidation ponds only if there is shallow, quiet water near the banks. Prompt removal of weeds from the shore line and the maintenance of good slope on the banks will eliminate all trouble from this source. Frequent surveys for evidence of mosquito breeding in the oxidation ponds at the U. S. Naval Station at Shoemaker, California, have failed to reveal their presence at any time. The so-called "mosquito fish," *gambusia affinis*, will thrive in a well-designed oxidation pond which is not overloaded and provides a factor of safety against mosquito breeding.

Design

Construction and use of sewage oxidation ponds should not be attempted where the soil is loose or sandy since in this case it would be impossible to maintain the required volume of water in the pond. Percolation plus evaporation rates exceeding 40,000 gal. per acre per day usually prohibit use of sewage ponds, unless the per capita sewage flow is unusually high. The percolation rate of most soils is reduced through the application of sewage.

Pretreatment

Only clarified sewage should be applied to oxidation ponds. Clarification may be accomplished in the standard settling tank with mechanical sludge removal or in an Imhoff tank. Even septic tanks have been used successfully but they are not recommended since the influent to the ponds is high in hydrogen sulfide and odorous.

Capacity Factors

Since satisfactory oxidation of sewage in oxidation ponds depends upon both detention time and exposure to sunlight, these criteria are used as a basis for their design. Experience in the operation of oxidation ponds has produced the following tentative arbitrary design figures for ponds which are to receive settled domestic sewage:

(a) Minimum detention time—25 days.
(b) Minimum surface area—1 acre per 400 contributory population.

For an average sewage flow of 100 gal. per capita per day, a depth of

approximately 3 ft. is required to satisfy the above requirements. The depth should never be less than 3 ft. in order to control growth of aquatic vegetation. Therefore, when the sewage flow is less than 100 g.c.d., the actual detention time will be longer than 25 days. The above loading figures correspond to an average clarified sewage B.O.D. loading of 45 lb. per acre per day or approximately 15 lb. per acre-ft. per day. Where sewage contains normal industrial wastes, it is permissible to use the latter figure in computing the total pond area for ponds not over 4 ft. in depth.

The above rules are offered for use in designing ponds in central and southern California and in Arizona. They may be applicable in other localities of similar climatic conditions.

Layout and Shape of Pond Area

The total pond area should be divided into two or more individual ponds operated in parallel, with flexible inlets and outlets to permit removal from service for cleaning. The maximum area of a single pond is limited only by the slope of the natural ground and the maximum size of the inlet and outlet structures.

Diffusion of Sewage

Incoming sewage must be mixed immediately with sufficient partially-treated, algae-bearing pond water to eliminate odors and septic areas. The dilution required has been the subject of study and it is believed necessary to distribute the sewage over the entire pond area if possible. At first glance this would seem to reduce the pond efficiency since a small fraction of sewage would escape without adequate treatment. It is believed, however, that the advantages gained for uniform distribution of sewage far outweigh the disadvantages. The short circuiting effect due to introducing sewage at the quarter points of a pond has been computed as approximately equal to that occurring by introducing all the sewage at one end and mixing with an equal quantity of recirculated effluent.

In the case of extremely large ponds such as are being considered by the San Jose Sanitary District in California, proper distribution and diffusion of settled sewage may be more economically accomplished through the use of open canals with provision for recirculation of effluent as shown in Figure 11. The required pumping lift for the recirculated portion of the flow would be only a few feet and high capacity propellor type pumps could be used to advantage. The quantity of recirculated effluent could be adjusted to maintain aerobic conditions in the ponds. The system shown in Figure 11 would be able to give secondary treatment to the sewage from a population equivalent of 375,000 persons throughout the year, while a loading of at least twice this figure could be effectively treated during the summer months.

A recent tentative design by Charles Gilman Hyde, Professor of Sanitary Engineering, Emeritus, University of California, for the town of Davis, California, is shown in Figure 12. In this design the total pond area (8 acres) has been divided into two individual ponds of 4 acres each. Settled sewage is diffused into the ponds over the first one-half of the area, leaving the last one-half free of sewage in order to obtain a high degree of bacterial purification.

Inlet and Outlet Designs

Details of suggested inlet and outlet designs are shown in Figure 13. It is important that settled sewage be distributed to the various ponds in proportion to their areas. This can be accomplished through the use of a distributing box after the primary treatment units or by proper setting of the overflow weirs. In the latter case, provision must be made in the outlet structure for adjustment of the overflow level.

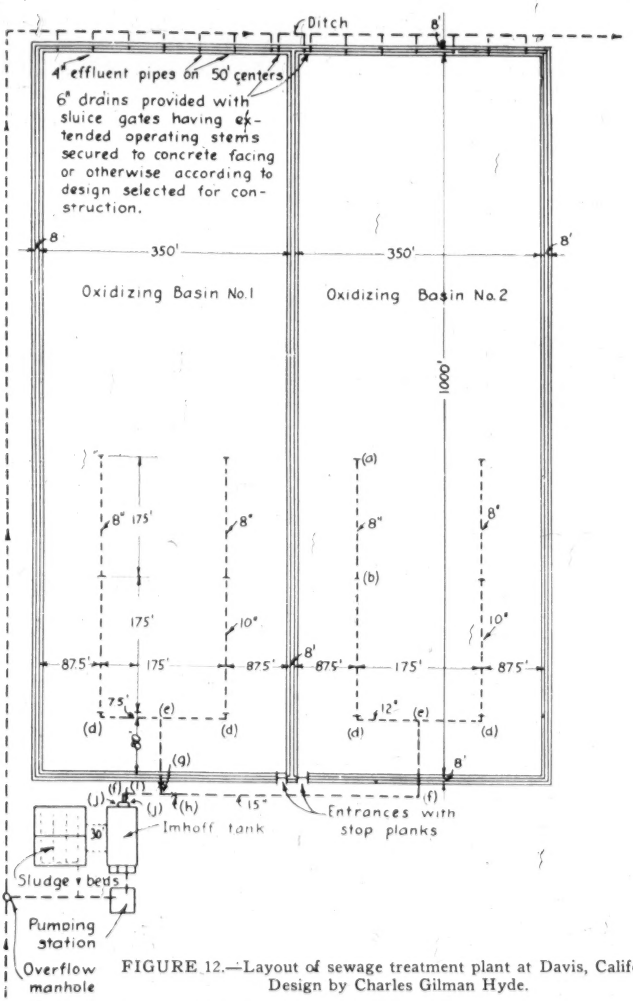
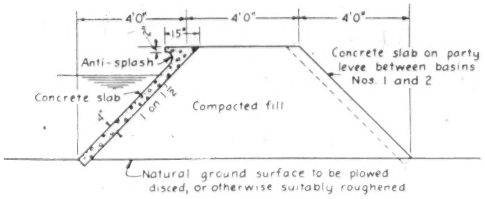


FIGURE 12.—Layout of sewage treatment plant at Davis, California. Design by Charles Gilman Hyde.

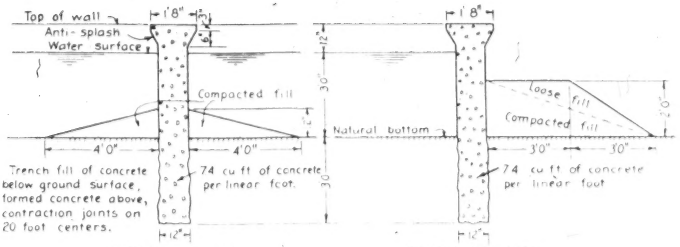
Note: V-C fittings on supply pipe lines to and in oxidizing basins at locations indicated. Pipes to be laid on smoothed ground surface with joints made with Petrolastic XX or equal. 24" × 48" × 4" concrete slab at each discharge tee, 12 required.

(a) 6" × 8" increaser; 6" double-tee branch, end plugged.
(b) 8" × 10" increaser; 8" × 4" double-tee branch.
(c) 10" × 3" double-tee branch; 3" side outlets or equivalent orifices.
(d) 10" × 12" increaser; 12" long radius 90° bend.
(e) 15" × 12" double-Y branch, end plugged; 2 12" long radius 45° bends.
(f) 15" long radius 90° bend.
(g) 15" Y branch; 15" long radius 45° bend.
(h) 15" gate valve.
(i) 2 12" long radius 45° bends; 15" × 12" double Y branch.
(j) 12" long radius 90° bend.

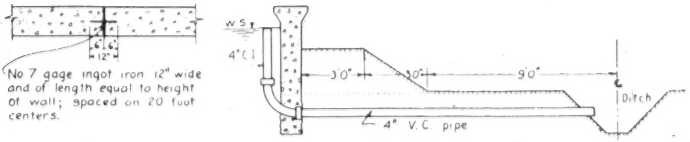


EARTHEN LEVEE WITH CONCRETE FACING

Note: Concrete slabs to be 10 feet long with approved separator strips between.



INTERIOR WALL EXTERIOR WALL



CONTRACTION JOINT SECTION THROUGH WALL SHOWING EFFLUENT PIPE

FIGURE 13.—Design details of sewage treatment plant at Davis, California. Design by Charles Gilman Hyde.

Walls or Banks

Earthen banks are satisfactory if properly constructed to resist seepage and erosion. A minimum top width of 8 ft. and at least 1 on 2 side slopes are recommended. Freeboard should be at least 2 ft. to avoid topping of the bank by pond water during strong winds.

For permanent installations, concrete walls such as illustrated in Figure 13 are more satisfactory than earthen banks since they eliminate shallow water which is conducive to weed and mosquito growth.

Summary

The subject of sewage oxidation ponds is discussed from the standpoints

of performance, operation and design. An attempt has been made to present performance data in a manner which would neither unduly praise nor discredit this type of treatment. It is believed that sewage oxidation ponds offer a satisfactory solution to the problem of sewage disposal where lands are available, not too costly and have fair isolation, and offer temporary solutions to problems of expansion of treatment facilities. Their limitations and disadvantages are also discussed.

Operating and design features are considered in the light of three years' operating experience at various installations in the southwestern states. Recommendations for the control of aquatic weeds and mosquitos are given. Suggested typical designs of oxidation pond treatment units are presented together with details of necessary appurtenances.

Acknowledgments

Data from the Shoemaker oxidation ponds were accumulated in connection with the routine operation of the sewage treatment plant under the general supervision of Lieut. J. B. Ackerman, CEC, USNR, head of the Sanitary Engineering Section, District Public Works Department, Twelfth Naval District. Permission to use the performance data from the Calistoga sewage ponds was given by the California State Department of Health through Mr. C. G. Gillespie, Chief, Bureau of Sanitary Engineering. The writer is indebted to Prof. C. G. Hyde and the town of Davis, California, for permission to reproduce the tentative design of the sewage oxidation ponds shown in Figure 12, and to Prof. Hyde and Prof. W. F. Langelier for their assistance in preparing this discussion.

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PLAIN AERATION OF SEWAGE*

By Uhl T. Mann

Chief Operator, Ley Creek Sewage Treatment Plant, Ley Creek Sanitary Sewer District, Onondaga; Public Works Commission, Syracuse, N. Y.

Unusal weather conditions at Syracuse in 1944 interfered seriously with the dewatering of sludge on drying beds, creating a problem of considerable magnitude. Records of the Syracuse Army Air Base showed that there were only 77 days of sunshine during the entire year and, as a result, it was impossible to dry and dispose of sludge as rapidly as it was produced in the course of conventional activated sludge operation of the plant. This led to the decision that it was absolutely imperative that the volume of sludge be reduced during the winter of 1944–5.

The problem of disposing of the large volumes of sludge produced is an acknowledged disadvantage of the activated sludge process. Of interest in this connection have been the studies of Setter and Edwards (1) (2) involving experiments with modified aeration. Eleven months of plant scale operation with modified aeration in 1944 showed (3) that a 30 per cent reduction in the volume of sludge produced was accomplished, as compared to the volume produced in 1943 when step aeration was employed.

As an emergency measure at the Ley Creek plant, for a period of six months beginning on November 5, 1944, one-half of the settled sewage flow was treated by plain aeration, *i.e.*, aeration without return of sludge. It is the purpose of this paper to present the results obtained during the six-month period. The literature on extended plant scale studies of plain aeration appears to be somewhat limited at this time, although Hatfield (4) has reported on a study of 133 days duration, in which short periods of aeration (averaging 2.48 hr.) were employed.

Description of Plant

The layout of the Ley Creek plant is illustrated in Figure 1. Sewage enters the plant by gravity and, after passage through a mechanically cleaned screen, is pumped to duplicate grit chambers.

The grit chambers are flanked by preaeration channels (Figure 2) through which the sewage may be passed before discharge to the four rectangular primary sedimentation tanks. The effluent from each primary tank may be put into a single one of the four aeration units or it may be combined for distribution to the aeration tanks as desired. The primary effluent may also be passed directly to the final settling tanks, to the final filter or to the outfall sewer. The primary tanks are equipped with flight collectors and sludge may be pumped to either of two conditioning tanks, to any one of the four digesters or directly to the drying beds. Scum and grease may be pumped to the digesters or drying beds, or it may be removed for separate disposal.

The aeration tanks are of the two-pass spiral flow type with a double row of diffuser plates in the first pass and a single row in the return. Air is provided by three positive displacement rotary blowers, of which two are electrically driven and one is driven by a gas engine (Figure 3).

The two final settling tanks are similar to the primary units, except for their greater effluent weir length. The sludge from the final tanks may be pumped to the aerators, the raw sewage, primary tanks, conditioning tanks, di-

* Presented at 18th Annual Meeting, New York State Sewage Works Assn., New York City, January 18, 1946.

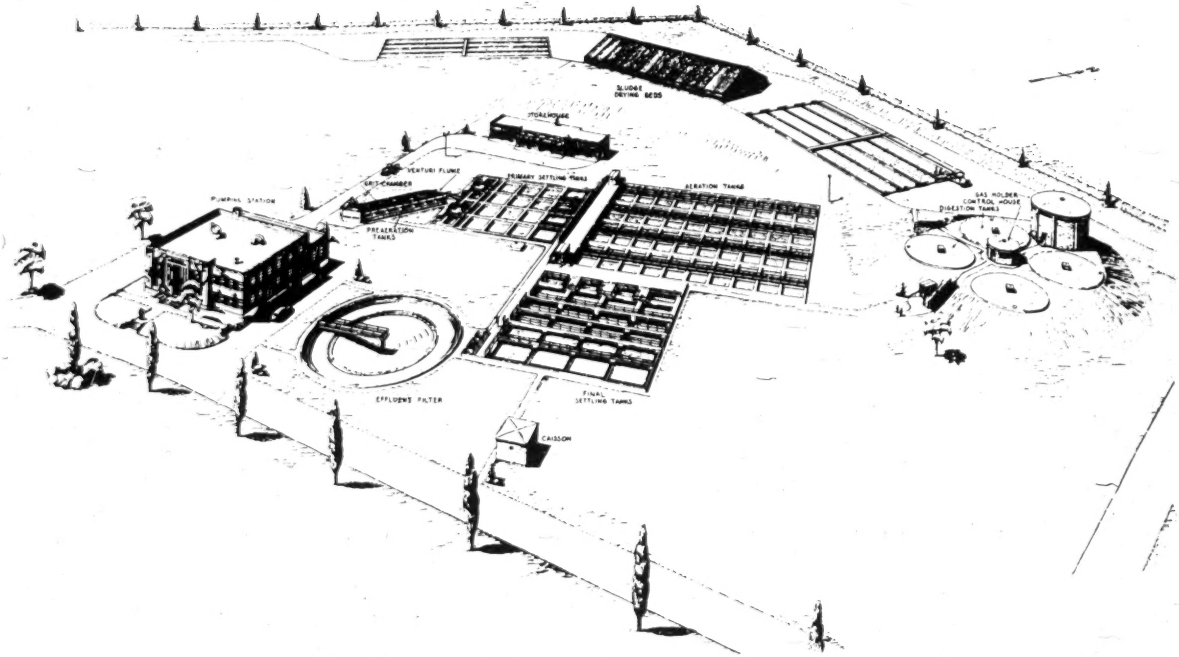

FIGURE 1.—Perspective sketch of Ley Creek sewage treatment plant.

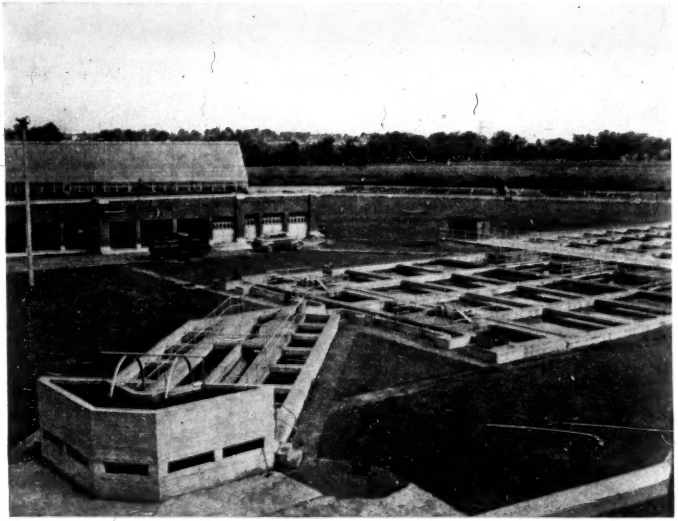

FIGURE 2.—Primary treatment units, Ley Creek sewage treatment plant. Grit chambers and preaeration unit at lower left; primary sedimentation tanks at right center.

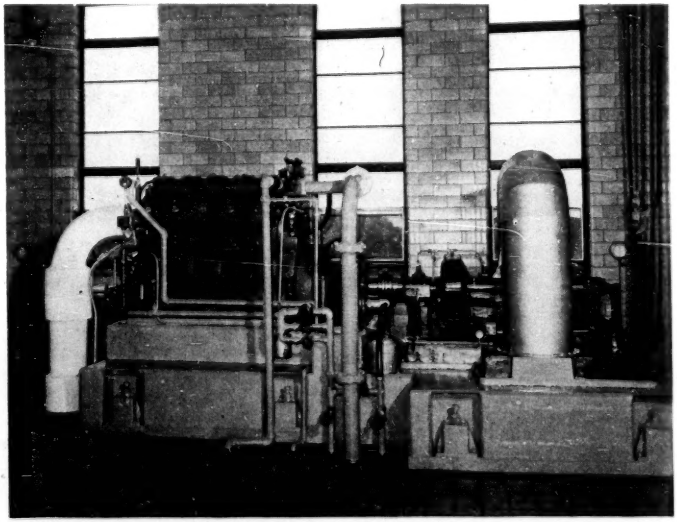

FIGURE 3.—Gas engine-driven blower. Ley Creek sewage treatment plant.

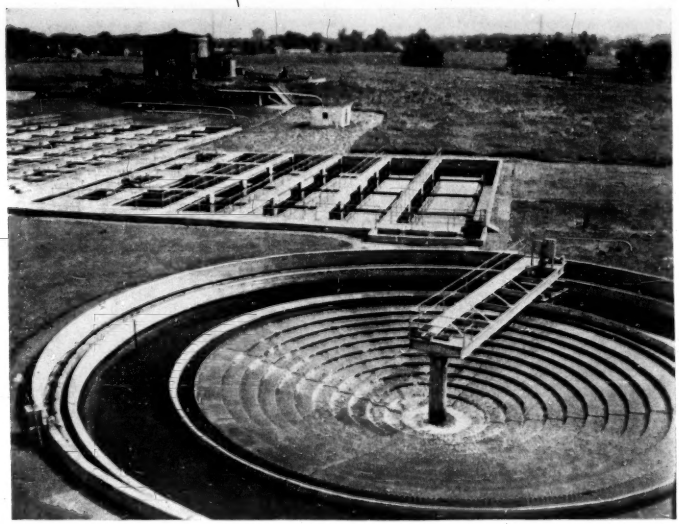

FIGURE 4.—Magnetite filter with center cascade at Ley Creek sewage treatment plant. Final settling tanks at center; aeration units and digesters at upper left.

gesters or to the drying beds. The pumping arrangement is very flexible, permitting the sludge to be cross-pumped to opposite pairs of aeration tanks. For instance, aerators Nos. 1 and 2 normally discharge to final tank No. 1, but it is possible to return sludge from that final settling tank to aerators Nos. 3 and 4.

The final tanks are followed by a down-flow magnetite filter having the novel feature of an interior concentric cascade that has the purpose of inducing atmospheric oxygenation of the final effluent (Figure 4).

The four digesters may be operated in single or multiple stage. Digester overflow passes to the tank of a 15,000-cu. ft. gas holder, where a long detention time is afforded for separation of supernatant solids before return of the liquor to the raw sewage. Both open and glass-covered drying beds are provided.

Facilities are available for applying chlorine to the raw sewage, final effluent, return sludge or at the preaeration tank.

The arrangement of the various parts of the plant is such that it may be operated as two separate units after the sewage has passed through the preaeration unit. Design data follow:

Design population	30,000
Design flow (m.g.d.)	4.5
Raw sewage pumps (m.g.d.)	10
Detention periods:	
Preaeration unit (min.)	14
Four primary tanks (hr.)	2
Four aeration tanks—without return sludge (hr.)	7.4
Two final settling tanks (hr.)	2.75
Magnetite filter rate (gal. per sq. ft. per min.)	2
Return sludge pumps (g.p.m.)	1,200
Blower capacity (c.f.m.)	1,000–6,000
Digester volume—four tanks (cu. ft.)	105,000
Sludge drying beds—open (sq. ft.)	30,000
Glass-covered (sq. ft.)	15,000

Volume and Character of Sludge

The plant received sewage from an estimated population of 24,000 plus an equivalent population of 10,000 in the form of industrial wastes plus the fluctuating population load of an army bomber base. Industrial wastes are received from several machine shops, two slaughterhouses, a large rendering plant and a large war plant employing about 5,000 persons.

The average 5-day B.O.D. and suspended solids contents of the raw sewage during the six-months period of this study were 172 p.p.m. and 176 p.p.m., respectively. The B.O.D. ranged from 38 p.p.m. to 334 p.p.m. and the suspended solids from 77 p.p.m. to 365 p.p.m.

The average flow of sewage during the study was 4.59 m.g.d., which compares favorably with the design flow of 4.5 m.g.d. for activated sludge treatment. The flows during the 15th to 20th weeks, inclusive, were well above the design rate, with the average for the 17th week being more than twice the capacity of the plant for activated sludge treatment.

Operating Procedure

In the plain aeration study, one-half of the flow to the plant was treated in two aeration tanks. The valves in the lines between the primary tanks and the aerators were kept at full opening so that the aerators could take flows up to the capacity of the sewage pumps. Nothing was done to reduce the load on the plain aeration units in the course of the study. Supernatant liquor from the digesters and the drainage from the sludge drying beds were returned to the incoming sewage as in normal operation.

One-half of the air supplied by the gas engine-driven blower was used at the plain aeration tanks. In reporting the rates of air application, no correction was made for the air used in preaeration ahead of primary sedimentation or for the air used in the distribution channels between the aerators and final settling tanks. An average of 14 min. of preaeration was given all of the sewage before it entered the primary tanks.

All settled sludge from the final tank receiving the sewage treated by plain aeration was returned to the sewage entering the two primary tanks preceding the plain aeration units. The sludge developed settled rapidly and had the appearance and characteristics of raw sludge. The average solids content of the sludge from the final tank was 2.9 per cent as compared to the 1.5 per cent solids in activated sludge. No attempt was made to measure the amount of sludge removed at the final tank, but the daily volume handled at the primary tanks during the plain aeration study was 36 per cent less than the volume of combined sludge produced by activated sludge treatment, as measured by pumping times. The sludge from the final tank was held in the primaries about three hours before being pumped with the primary sludge to the digesters. The mixture of primary and plain aeration sludges averaged 5 to 6 per cent solids.

During October, 1945, one-day tests were run by controlling the flow to the aerators in service. Data were secured on plain aeration for detention periods of from 2 to 8 hr. and from 8 to 35 hr.

At the start of these studies, it was intended to include the magnetite filter throughout but this plan had to be abandoned because of the unusually heavy snowfall during the winter, which made it impossible to operate the filter. For a period of nine days, however, from October 26 to November 4, the normal flow was treated by plain aeration followed by final filtration.

Laboratory data reported here are from the daily records of the plant analyst. Where weekly averages are used, they represent six daily determinations made on 24-hr. composite samples. No analyses were made on Sundays or holidays.

Results

Operating and analytical data summarizing the results of the six months of study of plain aeration are presented in Table I.

The average reduction in suspended solids by primary settling was 52.5 per cent and plain aeration with final sedimentation yielded a secondary reduction of 62.5 per cent. The overall removal of suspended matter accomplished by the two steps of treatment averaged 82 per cent for the entire six months. The range in overall removal was from a low of 61 per cent to a high of 90 per cent.

Removals of 5-day B.O.D. were 54.8 per cent by primary treatment and 71.5 per cent by plain aeration and final settling. The average overall removal of B.O.D. for the entire study was 87 per cent, ranging from 53 to 93 per cent. On several days of excessively high flows, the actual removals in pounds of B.O.D. and suspended matter were greater than would have resulted had the plant been operating by the conventional activated sludge process, assuming that all flows above the design rate would have been bypassed after primary treatment.

For nine days in December, 1945, studies were made of plain aeration at controlled detention times of from 2 to 35 hr. The relation between B.O.D. removal and aeration period, as determined from these studies, is represented by the data contained in Table II and shown graphically in figure 5. It will be noted that the removal curve rises very sharply during the range of 2 to 8 hr. At the 8-hr. point, the curve

TABLE I. Plain Aeration Results. Summary of Operation and Analytical Data. November 5, 1944 to April 28, 1945

Week No.	Average Daily Flow (m.g.d.)	Ave. Temp. (°F.)	Suspended Solids (p.p.m.)				5-Day B.O.D. (p.p.m.)				Applied Air (cu. ft.)		Detention Period (hr.)
			Raw Sewage	Prim. Eff.	Final Eff.	Per Cent Removal-R/F	Raw Sewage	Prim. Eff.	Final Eff.	Per Cent Removal-R/F	Per Gallon	Per Lb. B.O.D. Removed	
1	3.09	50	282	75	29	89	191	82	24	87	0.77	1600	10.7
2	2.77	50	263	105	39	85	312	123	26	91	0.88	1090	12.1
3	2.80	49	365	107	36	90	276	124	22	92	0.87	1030	11.8
4	2.83	50	211	106	35	83	189	106	21	89	0.86	1220	11.7
5	3.89	50	181	88	28	84	164	77	23	86	0.62	1380	8.5
6	4.67	50	144	89	21	85	140	75	16	88	0.52	1060	7.1
7	3.82	48	238	77	29	87	205	75	23	89	0.63	1450	8.7
8	3.50	46	254	97	32	87	196	82	21	89	0.69	1370	9.5
9	4.36	42	135	64	26	80	165	81	22	86	0.55	1130	7.6
10	3.92	50	167	98	35	79	334	121	21	93	0.62	740	8.5
11	3.27	48	198	119	41	79	227	110	24	89	0.74	1030	11.2
12	3.03	47	175	80	36	79	235	122	23	89	0.80	950	10.8
13	3.92	44	176	105	42	76	134	76	25	81	0.62	1450	8.5
14	3.62	46	167	79	30	82	153	63	25	83	0.67	2100	9.2
15	5.45	48	178	91	23	87	137	59	25	82	0.44	1540	6.1
16	6.89	43	130	62	39	70	136	61	22	83	0.35	1090	4.8
17	9.26	44	86	61	29	66	38	25	16	58	0.25	2000	3.6
18	8.20	46	77	59	23	70	46	23	19	59	0.29	2180	4.0
19	5.63	47	136	73	24	82	57	35	24	53	0.43	1000	5.9
20	7.25	48	120	67	33	72	108	43	20	81	0.33	1730	4.6
21	5.89	50	95	57	37	61	121	79	25	79	0.41	910	5.6
22	4.69	51	117	62	20	82	148	88	27	81	0.51	1000	7.1
23	3.98	52	187	93	27	85	225	82	23	90	0.61	1225	8.3
24	3.41	51	138	71	20	85	191	54	24	87	0.71	4200	9.7
Ave.	4.59	48	176	83	31	82	172	78	22	87	0.59	1436	8.2

TABLE II.—B.O.D. Reduction at Various Detention Periods by Plain Aeration of Settled Sewage, December 15–24, 1945

Day Number	Sewage Flow (m.g.d.)	Aerators in Service	5-Day B.O.D. (p.p.m.)			Aeration Period (hrs.)	Applied Air (cu. ft. per gal.)
			Aerator Inf.	Final Tank Eff.	Reduction (%)		
1	3.93	1	102	55	46.0	2.10	0.40
2	3.17	1	92	44	52.3	2.62	0.50
3	2.14	1	127	42	67.0	3.87	0.74
4	4.01	2	113	35	69.1	4.10	0.39
5	4.25	3	123	35	71.6	5.82	0.37
6	4.13	3	99	21	78.9	6.00	0.38
7	3.97	4	112	21	81.3	8.40	0.40
8	3.30	4	106	20	81.5	10.0	0.48
9	2.20	4	106	19	82.0	15.0	0.72
9	1.65	4	106	20	81.5	20.0	0.96
9	1.34	4	106	19	82.5	25.0	1.18
9	1.10	4	106	19	82.5	30.0	1.44
9	0.94	4	106	18	83.0	35.0	1.68

Note: Last five runs sampled at 5-hr. intervals.

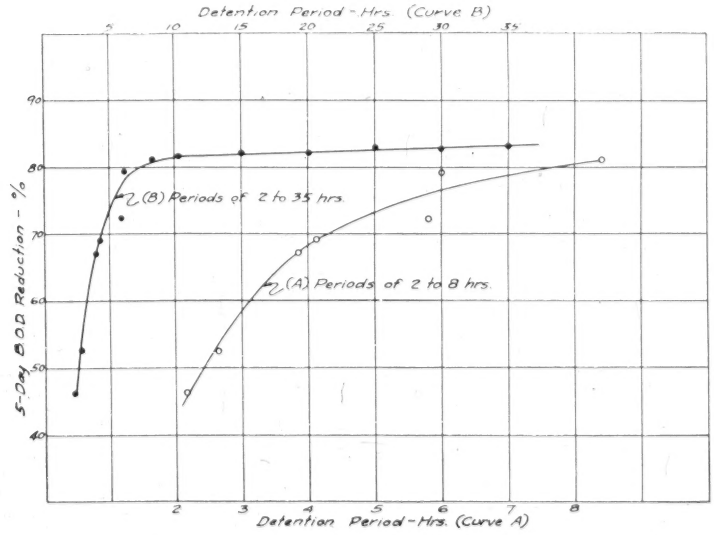

FIGURE 5.—Relation between B.O.D. reduction and detention in treatment of settled sewage by plain aeration.

levels off but continues upward very gradually, the increase in B.O.D. removal between 8 hr. and 35 hr. of plain aeration amounting only to about 2 per cent. The percentage removal found at 8.4 hr. of aeration was 81 per cent, while 35 hr. of aeration gave a removal of only 83 per cent.

Table III presents the data gathered during a 9-day period in October and

TABLE III.—Comparison of Removals of Suspended Solids and 5-Day B.O.D. at Three Stages of Treatment, October 26–November 4, 1945

Day Number	Sewage Flow (m.g.d.)	Aeration Period (hrs.)	Applied Air (cu. ft. per gal.)	Suspended Solids							5-Day B.O.D.						
				Raw Sewage (p.p.m.)	Prim. Eff. (p.p.m.)	Per Cent Removal (1)	Pl. Aer. Eff. (p.p.m.)	Per Cent Removal (2)	Filt. Eff. (p.p.m.)	Per Cent Removal (3)	Raw Sewage (p.p.m.)	Prim. Eff. (p.p.m.)	Per Cent Removal (1)	Pl. Aer. Eff. (p.p.m.)	Per Cent Removal (2)	Filt. Eff. (p.p.m.)	Per Cent Removal (3)
1	3.27	10.0	0.48	177	71	60	29	83	18	90	180	81	55	27	85	18	90
2	3.06	10.8	0.52	184	77	58	37	80	25	92	168	102	39	30	82	20	87
3	3.10	10.6	0.51	149	72	51	34	72	20	86	264	99	62	29	89	21	92
4	2.70	12.2	0.59	188	101	46	32	82	25	87	198	78	60	25	87	17	91
5	2.92	11.3	0.54	126	73	42	28	73	20	84	175	94	46	25	85	19	89
6	3.08	10.7	0.51	178	76	57	40	77	25	86	126	80	36	22	82	16	87
7	3.14	10.5	0.50	205	86	58	29	86	21	90	138	72	43	23	83	18	87
8	2.81	11.7	0.56	199	81	59	36	82	22	89	162	84	48	23	85	20	87
9	3.10	10.6	0.51	164	65	60	41	75	26	84	210	90	57	21	90	16	92
Ave.	3.02	10.9	0.52	174	78	54.5	34	78.8	22	87.5	180	85	51.7	25	85.3	19	89.1

(1) Removal by primary treatment.
(2) Overall removal by primary treatment plus plain aeration and settling.
(3) Overall removal by primary treatment plus plain aeration and settling plus magnetite filter.

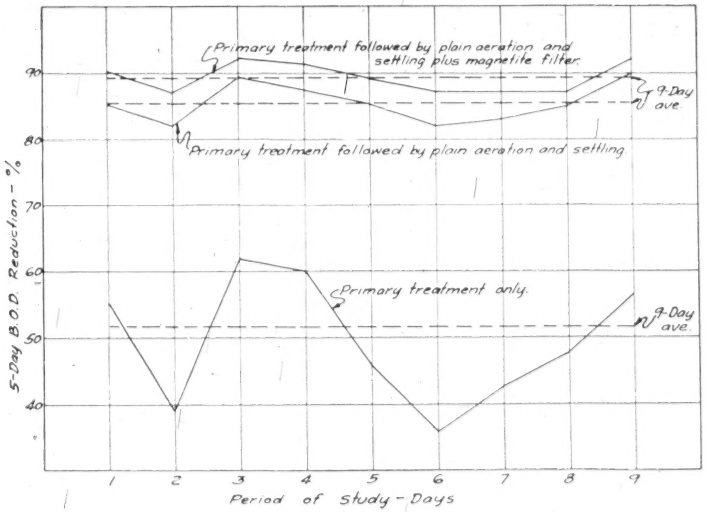

FIGURE 6.—B.O.D. reductions at three stages of treatment.

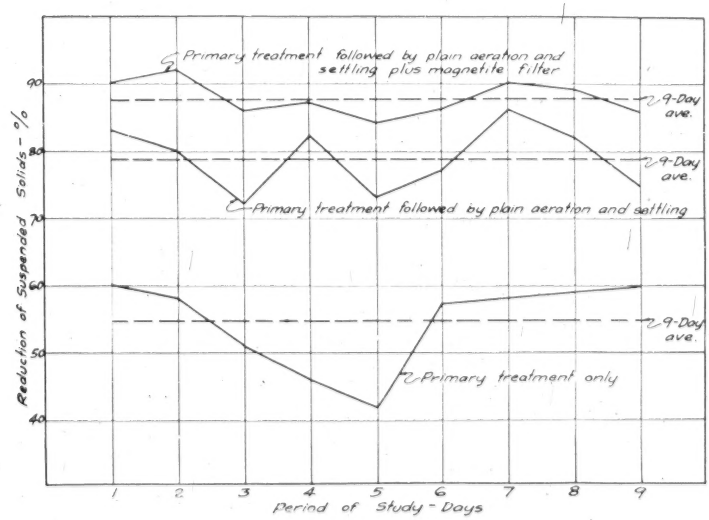

FIGURE 7.—Suspended solids reductions at three stages of treatment.

November, 1945, at which time the magnetite filter was used to "polish" the plain aeration effluent. These data are plotted in Figures 6 and 7. The three steps at which removals are compared are (a) primary treatment, (b) primary treatment plus plain aeration and settling and (c) primary treatment plus plain aeration and settling plus treatment by the magnetite filter. The average progressive removals of suspended solids and B.O.D., respectively, were 54.5 and 51.7 per cent at the first stage, 78.7 and 85.3 per cent at the second stage, and 87.5 and 89.1 per cent at the third stage of treatment.

Figure 8 compares the air required in cu. ft. per pound of B.O.D. removed by plain aeration with typical air requirements when the plant was operating by the activated sludge process. The data plotted for plain aeration are taken from Table I while the data representing activated sludge air requirements are taken from Table IV, which was included in a previously published report (5) on the plant.

Observations

A most interesting observation during the six months of treatment by plain aeration and settling is the uniformity of the effluent B.O.D. With a variation from 23 p.p.m. to 124 p.p.m. of B.O.D. in the sewage received for plain aeration, the B.O.D. of the aerated and settled effluent was consistently in the low 20's. On only three occasions did the effluent B.O.D. drop below 20 p.p.m. but at two of these times the incoming sewage had a very low B.O.D. as a result of high flows.

The trend in B.O.D. of the activated sludge effluent, as shown in Table IV, is considerably lower than that of the effluent during treatment by plain aeration, but there is considerably more variation.

The suspended matter content of the plain aeration effluent, unlike the

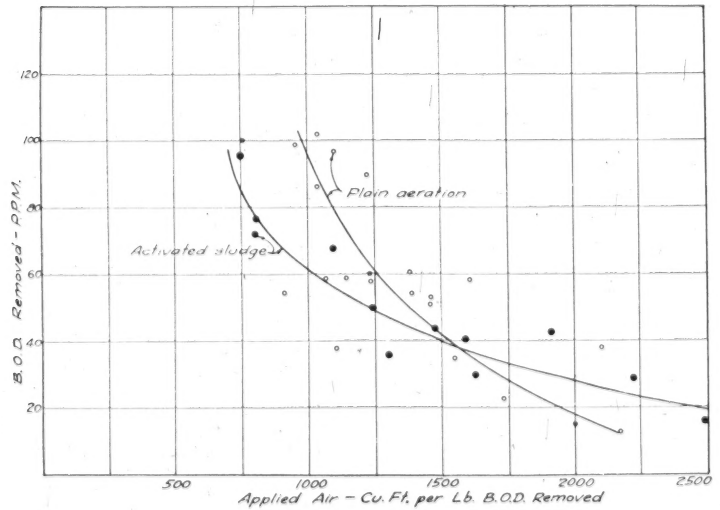

FIGURE 8.—Relation between B.O.D. removal and air used in plain aeration and in activated sludge process.

TABLE IV.—Activated Sludge Plant Operation Data—March 4 to May 26, 1945

Week Number	Sewage Flow (m.g.d.)	Sewage Temp. (°F.)	Suspended Solids				5-Day B.O.D.				Applied Air		Aeration Period (hr.)	Sludge Index
			Raw Sewage (p.p.m.)	Prim. Eff. (p.p.m.)	Final Eff. (p.p.m.)	Removal-R/F (%)	Raw Sewage (p.p.m.)	Prim. Eff. (p.p.m.)	Final Eff. (p.p.m.)	Removal-R/F (%)	Cu. Ft. per Gal.	Cu. Ft. per Lb. B.O.D. Rem.		
1	6.59	44	73	59	13	73	37	21	5	82	0.37	2520	4.2	37
2	5.63	47	133	70	8	93	57	35	5	88	0.43	1620	5.1	46
3	6.24	47	120	67	6	95	108	43	7	93	0.39	1300	4.5	43
4	5.87	47	95	57	11	87	121	79	7	93	0.41	795	4.8	41
5	4.69	50	110	58	4	96	148	87	10	93	0.52	807	6.3	49
6	3.98	51	177	88	5	96	217	78	10	93	0.62	1090	7.5	57
7	3.42	50	129	68	12	94	191	54	11	93	0.71	1920	8.9	64
8	5.54	51	178	77	7	95	192	62	12	94	0.52	1240	6.4	53
9	4.49	53	125	70	10	92	97	39	10	83	0.54	2230	6.6	55
10	4.44	50	109	68	4	96	90	47	6	93	0.54	1580	6.7	56
11	4.49	52	189	66	4	97	191	51	7	95	0.54	1470	6.5	59
12	4.14	54	256	71	3	98	313	105	9	97	0.59	740	7.3	67
Ave.	4.96	49	141	68	7	93	147	58	8	91	0.51	1440	6.2	52

Note: (a) Aeration tank solids ranged from 1,500 to 1,800 p.p.m.
(b) Return sludge solids ranged from 8,000 to 12,000 p.p.m.
(c) Return sludge to aeration tanks averaged 15 to 20 per cent.

B.O.D., did not show any degree of consistency.

Removals of B.O.D. and suspended solids were considered very good, both approaching 90 per cent. Plain aeration treatment gives higher percentage removals of B.O.D. than of suspended solids, whereas the reverse is usually true when treatment is by activated sludge. The difference in the removal of B.O.D. per cu. ft. of applied air is very slight when comparison is made between treatment by plain aeration and activated sludge. Increasing the amount of air applied in plain aeration did not noticeably increase the reductions of suspended solids and B.O.D.

Aerobic conditions were maintained in the aerators and final settling tanks for the entire duration of the study. The dissolved oxygen content of the sewage under treatment in the aerators and in the final settling tank averaged 4 to 6 p.p.m., which range still obtained when an aeration period of 33 hr. and a final settling tank detention period of 12 hr. were being used.

For the most part, the effluent was very turbid and not until 20 to 25 hr. of aeration was afforded did the contents of the final settling tank attain any degree of clarity. Even with the longer aeration periods, however, the effluent did not approach the sparkling appearance that is typical of the effluent from the activated sludge process. Turbidity of the effluent was not as great when the flow to the aerators was continuous as it was when the flows were intermittent.

The greater part of the floc visible in the aeration tanks was gray in color and in stringy clumps about 1 in. long. Upon settling, the stringy appearance was lost and, after compacting, the sludge was similar in appearance to primary sludge, although of a much fluffier nature.

When an aeration tank which had been emptied for inspection and cleaning was put back into service as a plain aeration unit, it was about 17 days before satisfactory results in B.O.D. and suspended matter reduction obtained. This would indicate that the mechanism of plain aeration involves biochemical as well as physical action.

No data are available to illustrate the effect, if any, of preaeration of the sewage before primary sedimentation on the final results secured by plain aeration treatment.

Conclusions

1. Plain aeration and settling will afford a positive degree of treatment between the limits of primary treatment and activated sludge treatment. Plain aeration is not suggested as a substitute for the activated sludge process but it might be worthy of consideration as a temporary emergency procedure in activated sludge plants.

2. The most important advantage of plain aeration, as practiced in these studies, is the reduction in volume (by virtue of increased concentration) of the mixture of primary and secondary sludges that is produced. It is the author's opinion that the use of plain aeration as a cold weather method of operation may be justified in localities where drying beds are not usable during winter months.

3. Plain aeration might also be advantageously applied for pretreatment where conventional secondary treatment units are seriously overloaded or where they are subjected to abrupt shocks of strong industrial wastes. The results of these studies indicate that shock loads may be tapered off and that effective reduction in load on following secondary treatment units may be expected, and that economies in air requirements and sludge handling may be accomplished. Further study in support of this conclusion is recommended.

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PLAIN AERATION OF SEWAGE—A DISCUSSION

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Mr. Mann is to be commended for his contribution to the art and science of sewage treatment.

Predicated on the necessity of decreasing the volume of sludge in order to relieve the sludge drying beds, one-half of the Ley Creek activated sludge plant was operated without the return of sludge to the aerators for 6 months. It was estimated that for every 100 cu. ft. of mixed activated and primary sludge, there were produced only 64 cu. ft. of mixed aerated sludge and primary sludge. It may be calculated that of the 36 cu. ft. reduction in sludge volume, roughly 13 cu. ft. was due to a decreased plant efficiency and presumably 23 cu. ft. or about $\frac{2}{3}$ of the reduction was due to the greater compactness of the mixed aerated and primary sludges sent to the digesters. The paper does not indicate the degree of relief given to the sand drying beds by this method of operation on one-half of the plant flow, but the operation has added to our knowledge of the advantages and limitations of sewage aeration.

The salient information is contained in Table I of Mr. Mann's paper, which presents data secured during 24 weeks of aeration with no sludge return. The 9-day study of one or more average aeration periods per day is too short for judicial interpretation. The 9-day study of sewage aeration followed by filtering the final settling tank effluent through a magnetite filter is interesting. This study covers a period of dry weather flow which, exclusive of the filter, yielded results similar to those obtained in 14 previous dry weather weeks. The filter removed an average of 11.5 p.p.m. suspended solids and 6 p.p.m. B.O.D. Although this is a significant improvement, it may be wise to withhold interpretation until a longer period of filter performance is established.

Upon inspection of the aforesaid Table I, it was observed that the average suspended solids and B.O.D. load arriving at the plant from one week to the next was quite constant. Furthermore, beginning with the 15th week, there were 8 continuous weeks of relatively high average flow which gave aeration periods varying from 3.6 to 7.1 hr. Two other weeks, namely the 6th and 9th, were also weeks of high average flow. The remaining 14 weeks of relatively low average flow gave aeration periods of 8.3 to 12.1 hr. The weekly results for these two periods of "predominantly wet" and "predominantly dry" weather were averaged to obtain mean performances that could be compared with each other and with information from other sources.

The salient data from Ley Creek, Decatur (1), Indianapolis (3), and Ward's Island (2) sewage aeration are summarized in Table A along with the data on modified sewage aeration from

TABLE A.—Comparison Between Plain Aeration and Modified Aeration of Sewage

	Length of Investigation (weeks)	Aeration Period (hr.)	Applied Air			Index	Removals (p.p.m.)		Effluent (p.p.m.)	Removals (%)		Aer. Tank Susp. Sol. (p.p.m.)	Reference to Fig. A (point no.)
			Cu. Ft. per Gal.	Sec. Treat.—Cu. Ft. per Lb. B.O.D. Rem.	Overall—Cu. Ft. per Lb. B.O.D. Rem.		Sec. Treat.	Overall		Sec. Treat.	Overall		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Plain Aeration													
Decatur, Ill.	19	2.5	0.41	1,170	—	S.S.	0	—	—	0	—	105	1
						B.O.D.	42	—	84	33	—		
Ley Creek Plt.—Syracuse, N. Y.	10	5.6	0.41	1,380	555	S.S.	41	94.5	27.3	60	77.5	68.5	3&6
						B.O.D.	35.5	88.5	21.5	62.3	80.4		
Ley Creek Plt.—Syracuse, N. Y.	14	10.0	0.72	1,240	445	S.S.	60	181	33	64.5	84.5	93	4&5
						B.O.D.	69.5	193.5	23	75.5	89.4		
Indianapolis, Ind.	—	7.5	0.41	—	290	S.S.	—	232	77	—	75	220	7
			0.56	—	380	B.O.D.	—	173	93	—	65	250	
Ward's Island, N. Y.[a]	28	6.3	0.36	844	494	S.S.	30	89	54	36	60	230	8
						B.O.D.	51	87	33	60	70		
Ward's Island, N. Y. (Exp.)	9	0.76	0.5	1,600	—	S.S.	51	—	75	40	—	112	2
						B.O.D.	37	—	81	31	—		
		6.2	1.15	1,700	—	S.S.	95.5	—	16.5	85	—	136	
						B.O.D.	81.5	—	22.5	75	—		

(a) Seven battery months of test data at Ward's Island at batteries B, C and D, March to May, 1945. Unpublished data supplied by G. P. Edwards.

TABLE A (Cont.)—Comparison Between Plain Aeration and Modified Aeration of Sewage

	Length of Investigation (weeks)	Aeration Period (hr.)	Applied Air			Index	Removals (p.p.m.)		Effluent (p.p.m.)	Removals (%)		Aer. Tank Susp. Sol. (p.p.m.)	Reference to Fig. A (point no.)
			Cu. Ft. per Gal.	Sec. Treat.—Cu. Ft. per Lb. B.O.D. Rem.	Overall—Cu. Ft. per Lb. B.O.D. Rem.		Sec. Treat.	Overall		Sec. Treat.	Overall		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Modified Aeration													
Ward's Island, N. Y. (Exp.)	40	0.65	0.5	1,000	—	S.S.	80	—	40	66.5	—	145	12
						B.O.D.	58	—	59	49.5	—		
		5.15	1.15	1,460	—	S.S.	116	—	17	87	—	530	
						B.O.D.	94	—	15	86	—		
Jamaica, N. Y. (1944)	16	2.3	0.39	—	560	S.S.	—	183	35	—	84	500	9
						B.O.D.	—	83	36	—	69.7		
	8	4.8	0.34	—	364	S.S.	—	194	30.3	—	86.5	480	
						B.O.D.	—	111.5	33.5	—	76.9		
Bowery Bay, N. Y.	48	2.5	0.39	590	310	S.S.	84	165	29	74.3	85.1	505	11[c]
						B.O.D.	79	150	24	76.8	86.2		
Jamaica, N. Y. (1945)[b]	52	2.5	0.33	—	388	S.S.	—	162.6	32.4	—	83.4	600	10
						B.O.D.	—	101.7	31.8	—	76.2		
Jamaica, N. Y. (Summer, 1945)[c]	16	2.5	0.31	—	382	S.S.	—	148.5	25.5	—	85.4	600	11
						B.O.D.	—	97.2	24.8	—	79.7		

(b) Yearly average performance (unpublished). An average raw aerated sludge volume of 500 cu. ft. per m.g. of sewage treated was produced at a mean concentration of 5.9 per cent, of which 70 per cent is volatile.

(c) Four-month (June to September) average summer performance (unpublished). Points 11 on Figure A also represent the mean suspended solids and B.O.D. remaining during 11 months of modified sewage aeration at the Bowery Bay plant (5).

the Ward's Island experimental plant, Bowery Bay (5), and Jamaica (4). Columns 1 to 6 summarize the type of aeration, length of study in weeks, aeration periods in hours, and the air supply in cu. ft. per gal. and in cu. ft. per lb. of B.O.D. removed by secondary treatment and by overall treatment, respectively.

The removal in p.p.m. achieved by secondary treatment and the overall treatment appear in columns 8 and 9, while the percentage removal appears in columns 11 and 12. The p.p.m. impurities in the final settling tank effluent is shown in column 10. Both suspended solids and B.O.D. are given in columns 8 to 12 as shown in column 7. The aeration tank suspended solids is shown in column 13.

An inspection of the table will indicate:

(1) Data on sewage aeration and modified aeration include periods of from 0.75 to 7.5 hr. of aeration.

(2) The Ley Creek data on dry weather flow has extended our knowledge to include 10 hr. of sewage aeration.

(3) From 0.31 to 0.72 cu. ft. of air per gal. of sewage has been used for aeration, exclusive of the high experimental values.

(4) From 590 to 1,380 cu. ft. of air were used per lb. of B.O.D. removed by secondary treatment.

(5) From 290 to 560 cu. ft. of air were used per lb. of B.O.D. removed by the overall treatment.

(6) The removal of suspended solids and B.O.D. depends primarily upon the initial sewage strength, the length of the aeration period and the type of aeration employed. Except in three plant studies, an average of suspended solids and B.O.D. in the effluent was less than 35 and more than 25 p.p.m. The high effluent impurities at Decatur can be explained by the very short sewage aeration period on an Imhoff tank effluent containing a variable amount of starch wastes, troubles due to *Sphaerotilus* growths, and some difficulty in maintaining aerobic conditions in the aeration units. The high effluent impurities at Indianapolis can be explained by the very strong sewage containing ground garbage. The Indianapolis plant produced the greatest overall removal in p.p.m. but the percentage of removal was low.

(7) For sewage aeration, the aerator suspended solids varied from 70 to 136 p.p.m., except for the Indianapolis and Ward's Island sewages. For modified sewage aeration, the aerator suspended solids are currently held at 400 to 600 p.p.m. and the aeration period is comparatively short.

In presenting a logical pattern of performance achieved by different plants, it was convenient to plot the percentage of impurities remaining in the effluent as obtained by deducting the percentage removal from 100. The resultant data are plotted in Figure A against the aeration period in hours.

Curve 2 represents the mean results of Ward's Island pilot plant tests (2) on aeration of settled sewage. Although the suspended solids removal was greater than the B.O.D. removal, the curve shown is an average of both indices.

If curve 2 is to be extended to include sewage aeration at Ley Creek (points 3 for wet weather and points 4 for dry weather) the downward slope of the curve should be gradually flattened beyond 5 to 6 hr. of aeration to a value of 30 per cent remaining for 10 hr. of aeration. This means that a greater than normal rate of diminishing returns applies for relatively long periods of sewage aeration. Assuming 50 per cent removal by primary settling, a new curve drawn approximately parallel to curve 2, but starting at 50 per cent remaining for zero aeration, would indicate the overall treatment for varying periods of sewage aeration. The overall percentage of suspended solids and B.O.D. remaining in the

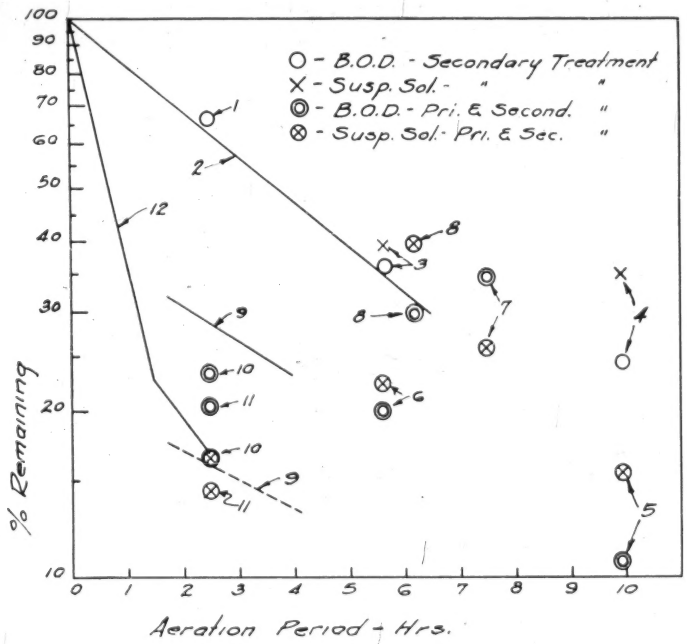

FIGURE A.—Comparative performance of plain aeration and modified sewage aeration. See text for explanation.

effluent is shown by the crossed circle and the double circle, respectively. It will be noted that the Ley Creek points 5 and 6 for dry and wet weather fall very near to this new hypothetical overall performance curve. The Indianapolis results, however (points 7), and the Ward's Island results (points 8) for sewage aeration fall short of the anticipated performance.

The lower left hand section of Figure A portrays the data on modified sewage aeration. Curve 12 was reproduced from previous pilot plant studies (2), wherein presettled sewage was aerated and sludge was returned to maintain an average of 400 p.p.m. aerator solids. Just as in the case of curve 2, it is the average of suspended solids and B.O.D. remaining in the effluent. When only 200 p.p.m. aerator solids were maintained, the performance curve was intermediate between curves 2 and 12. The solid line, curve 9, and the broken line curve of the same number are a reproduction of the first year of experimental operation at the Jamaica plant in 1943–44 (4). Points 10 represent the 1945 yearly performance of the Jamaica plant. Since there is no presettling of sewage, the results are those of overall performances. Points 11 are included to show the summer performance at Jamaica from June 1 to October 1, 1945. Eleven months of modified sewage aeration at Bowery Bay in 1944 gave a suspended solids and B.O.D. removal just slightly superior to the 1945 summer results of Jamaica.

The excess sludge from modified aeration at Jamaica can be readily thickened to an average of 5.9 per cent solids containing 70 per cent volatile matter, or a volume of 500 or less cu. ft. of sludge per m.g. sewage. This relatively low sludge volume, coupled with the performance on a relatively short aeration period which conserves air supply, leads to the conclusion that modified sewage aeration may be preferred to plain sewage aeration.

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EFFECT OF FOOD WASTES ON SEWERS AND SEWAGE TREATMENT *

By Morris M. Cohn

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The Program Committee of the New Jersey Sewage Works Association has posed a straight-forward question—and wants a straight-forward answer. The question: What will be the effect of food wastes on sewers and sewage treatment plants? My answer: The effect will be beneficial but there are problems involved; but the problems are correctable and the benefits so far outweigh them that great ultimate advantages will result, not only to the public at large but to the sanitary engineering profession.

I wish it were as simple as that—and that you would be content with my simple answer. But it is not, and you will not, because the paths of pioneering have never been smooth. It is only in the light of history that we awaken to the realization that the things which once were revolutionary, by natural processes of progress, become necessities of a better scale of living.

Pioneering developments have always been treated with doubt and scorn. People ridiculed the steam engine and the steamboat. When Edison was trying to make an electric globe, a scientist said that Edison "was trying to do something which is impossible." In 1867, Joshua Coppersmith was arrested in New York City for attempting to extort funds from ignorant people for building a device that would convey a human voice over metallic wires. Seth Woodbury, in 1885, was prohibited by the Common Council of Lynn, Mass., from using rubber tires on his buggy. Even more to the point is the fact that, in England, up until 1815, it was a penal offense to discharge offensive matters into public sewers and these wastes were carried off in open watercourses. In 1815, it became permissible to drain homes into sewers and it was not until 1847, 32 years later, that this was made compulsory.

The first bathtub was used in the United States in 1842. It is reported that, two years later, the Philadelphia Council failed by a mere two votes to pass a law prohibiting taking a bath between November and March and that Boston passed a law prohibiting taking a bath without a doctor's order but never enforced the law and it was repealed in 1852. In Virginia each bathtub was taxed $30.

The plight of the pioneer was brought home strongly to me in 1934, 12 years ago, when sanitary engineers threw up their hands in horror when I proposed that sewers be used for the water carriage of properly-ground food wastes, mixed with sewage, and that the sewer be substituted for the backyard garbage can and the surface collection of putrefactive wastes. They laughed at Edison and Fulton and the telephone was ridiculed. Disbelievers cut down the first telegraph wires and the first man to sell anthracite coal in Philadelphia was evicted from the State of Pennsylvania. When my sanitary engineering friends, back a dozen years ago, viewed my proposal with alarm, my only consolation was the fact that a number of leading sanitary engineers and public health officials agreed that the proposal was good.

It was not surprising that some sanitary engineers viewed with alarm the idea of using sewers for the dual purpose of carrying sewage and equally obnoxious, dangerous food wastes. It was difficult to break with precedent;

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there had always been a complete divorcement of liquid wastes and solid wastes from community life and the idea of combining them into one water-carried waste was appalling. It is well for me that the first reaction, "Cohn must be mad," has been proven to be at least slightly exaggerated. That I have been proven professionally sane now permits me the sweet pleasure of saying to many 1934 disbelievers, "I told you so!"

Since I went far out on a limb twelve years ago in advocating, for the first time, the feasibility of the instantaneous disposal of food wastes from the home, via the sewer, in the same manner as we have gained freedom from the dry disposal sewage methods, I am sure I will be pardoned if I venture a prediction at this time. It is this:—the sewer system will be used for carrying properly ground food wastes because the public will want it; because benefits to health and the niceties of living will result; because the process is desirable, feasible and economically sound; because it will improve the professional status of the sanitary engineer who will thus provide improvements in health and comfort; and because it is our job not to limit our horizons to the mere handling of lowly community wastes, but to conceive new ways of advancing public health and public service. In my Sanitation Bureau in Schenectady, I have engineering charge of both sewage and refuse disposal—but it would be stifling to my professional pride if I viewed myself as a mere waste disposal engineer. Rather I see my calling as a part of the public health program of a progressive community and I hold dearly my responsibility to serve the health interests of our citizenry.

It may take some time to win over to this concept all of the engineers and public officials, but it took years to win us over to the pioneering ideas of yesteryear—and we now laugh at our own past stupidity. Slow as universal acceptance will be, the past decade has already witnessed the engineering acceptance of the principles of dual disposal and it behooves all sewage works men to be preparing for the dual disposal process.

The natural question, therefore, at this stage of the game, is, "What will be the effect on sewers and sewage treatment plants?"

Basic Principles of Dual Disposal

So much has been written about the combined handling of sewage and food wastes, and the actual combined disposal of sewage and ground garbage has been adopted or is contemplated in so many plants, and so much research has been devoted to the subject, that it seems unnecessary to review the principles of dual disposal. Yet, a restatement of fundamentals is in order.

The combined process of disposal is as natural as nature itself. It is based on irrefutable scientific facts. Food wastes and sewage are one and alike and they act alike. They are both highly organic; they are both dangerous to man; they both go through the same processes of decay; they can both be treated in the same treatment processes in the modern sewage treatment plant. The trouble in the past has been that no one had conceived the idea of grinding food remnants to make them suitable for transportation through home plumbing systems, through public sewers and through sewage treatment plants. The coarse, unbroken food remnants which many residents discharge into the public sewer system through toilets and slop sinks are a source of trouble to the sewer system and sewage treatment plant operators.

On all of my visits to sewage treatment plants, I am impressed with the large amounts of garbage floating on the surface of tanks and contained in the trash from bar screens. It is significant that sewage treatment plants grind sewage screenings in the modern manner and discharge them into the

sanitary sewage flow. In a sense, this is nothing more than the household grinder does for the individual householder, thus permitting him to discharge unwanted materials into the sewer system for immediate removal from his own surroundings.

But when food wastes are ground, they are reduced to a far more uniform character than sewage solids themselves. Consequently, they flow even more readily through public sewer systems, they cause no stoppages, and they are readily treated at sewage treatment plants.

How Household Grinders Work

We talk glibly about "the better life" and everyone dreams about the great postwar era with streamlined trains and wonderous automobiles and magical pharmaceuticals and an abundance of plastic and nylons and television and other great scientific developments. That same better life will include, I am certain, the elimination of the age-old custom of storing putrefactive, odor-producing, fly-breeding, wastes in the backyard and basement and the surface collection of this noxious material for separate disposal. It is evident that, in answer to strong public demand for the better things of life, a number of recognized manufacturers may some day build household food waste grinders. However, one device has been on the market for some twelve years and some 50,000 units were in service in over 300 communities at the outbreak of war when all civilian comfort items became museum pieces. It is best, therefore, to base conclusions concerning household grinding of food wastes on the operation of this known unit. The Disposall is an electrical grinder located under and connected to the kitchen sink. It consists of a shredding compartment of about 3 qt. capacity and a ¼ h.p. motor which operates the revolving base of the compartment. This revolving base carries impellers which force food wastes against shredding elements and convert the material into a uniform, finely shredded pulp. The action is much like grating vegetables and the solids are shredded to a size that will flow through clearances of under $\frac{1}{16}$-in. size into the sink drain, through a standardized trap. This device is installed in compliance with local plumbing regulations.

Water for grinding is supplied from the sink faucet, thus providing a system free from cross connections. The unit switch is actuated by placing the cover on the grinder opening in the sink and turning the handle to the "on" position. The unit runs only when the cover is safely locked in place. The installation of an ingenious device called a flow interlock in the cold water line is electrically linked to the Disposall control switch and only permits the grinder to operate when a predetermined amount of cold water is flowing from the faucet into the sink and grinder.

Normally, the interlock is set at approximately 6 to 8 qt. flow per minute. This amount of water, coupled with the centrifugal discharge of a semi-pump in the grinder discharge housing, produces a high speed scouring action in the sink drain line which assures greater freedom from sluggish drains than ever achieved before the use of a household grinder. The cold water solidifies greases and the Disposall's high speed grinding and aeration action "homogenizes" the particles into buoyant, non-congealing form.

In ordinary use, for grinding all kinds of food wastes, including bones but not inert materials such as glass, crockery, etc., the Disposall operates approximately one minute per capita per day. Extended minute-counter readings in one home indicate a per capita operation period of less than one-half minute per day.

Thus, the water use for grinding at a rate of flow of 1½ to 2 g.p.m. is between 1 and 2 gal. per capita per day. This figure is important to remember

when analyzing the effect of food waste grinding on sewage flow, on sewer loadings and on plant volumes.

How Much Food Wastes?

Based on national experience, it has become standard practice to assume that approximately one-half pound of garbage is produced per capita per day. This garbage is, in major extent, water and the solids are primarily organic in nature. Garbage contains from 70 to 80 per cent water and the solids are from 75 to 85 per cent organic. G. J. Schroepfer, in making his studies of the effect of garbage on the Minneapolis-St. Paul Sanitary District, used the figures ½ lb. of garbage per capita per day containing 70 per cent moisture. Of course, garbage production varies from community to community, from section of city to section of city, and from season to season.

On this basis, it is generally agreed that the solids contributed by food waste grinders will be approximately equal to the normal sewage solids. Assuming a sewage flow of 100 gal. per capita per day, and a sewage of 200 p.p.m. suspended solids, the sewage suspended solids will amount to 0.166 lb. per capita per day. With food wastes at 0.5 lb. per capita, containing 70 per cent moisture (or 0.6 lb. per capita containing 75 per cent water) the solids contribution from food wastes will be 0.15 lb. per capita per day. From the nature of the grinding operation, it is evident that some of these solids will be in dissolved form, thus making the assumption that sewage solids and food waste solids are equal, will be even more conservative than ever.

For the purpose of rule-of-thumb simplification, let me restate the basic assumptions of food waste grinding:

If every home in a community used a food waste grinder, (1) the total sewage flow would be increased approximately 1 to 2 gal. per capita per day, or a 1 to 2 per cent increase in flow; (2) the suspended solids in the mixed flow would be approximately doubled; (3) the B.O.D., based on the estimates of many observers, may be increased from 15 to 30 per cent.

Growth Will Be Gradual

It goes without saying that anything approaching universal use of home grinders is a long way in the future. It is doubtful if any of us here will live to see universal adoption during our professional careers. I have frequently estimated that this universal elimination of surface collection of putrefactive wastes will take a generation or more. We cannot expect to change habit and custom overnight. Based on past experiences with other household appliances, it is certain that it will be a long time before appreciable percentages of residents will purchase household grinders and discharge their processed wastes into the sewer system. In the meantime, however, certain sanitation-loving persons will want this new achievement and they will, as pioneers, pave the way for the "universal user," just as those hardy spirits who "got out and got under" by their confidence in the "horseless carriage" prepared the way for you and for me to have a modern automobile.

The gradual installation of home units is fortunate because it will permit the pioneers to have their freedom from the garbage can and still will make no noticeable effect on your sewer system and sewage treatment problems for many years to come. For a number of years, so limited a number of Disposalls will be connected to the sewer system that cities will be unable to find any appreciable effect on sewage flow or sewage quality by the most sensitive gages or laboratory analysis.

Let us prove these statements by using an estimate that 100 to 1,000 home grinders may be sold and installed in the next few years in a city of 100,000 population. Even if such sales did materialize, the effect on the loading

of the sewage treatment plant would be negligible and would have little effect upon the operation of the works or the type of effluent discharged from the plant.

Effect of 100 Grinders

If 100 families out of the approximate 20,000 families residing in the city were to use grinders, the amount of solids increase in the sewage flow would be 0.5 per cent of the present sewage flow. Even of less significance than this trivial increase in solids content of the sewage would be the increase in what one might call the organic loading on the system. Since the oxygen demand of foodwastes is approximately 15 per cent of that of sewage, the use of 100 grinders would result in an increase in loading of only 0.08 per cent. It can, therefore, be seen that the organic loading on the sewage treatment plant will be practically unmeasurable under even the most sensitive accuracy standards established in any sanitary laboratory. Actually, accuracies of 1 per cent are difficult to attain, and therefore the increase on both sewage solids and organic loading will be impossible to find. At Schenectady, N. Y., where several hundred Disposalls are installed on a system treating approximately 10 m.g.d. of sewage, it has never been possible to analyze the difference between the quality of sewage without the food wastes and with the food wastes.

City officials will be interested in the effect of the use of 100 grinders on the sewer system itself. The actual use of water for operating and flushing the device amounts to approximately 1 gal. of water per person per day. Since 100 units will serve less than 500 persons, the maximum increase in sewage flow will be approximately 500 g.p.d. If the normal sewage flow of a city of 100,000 population is 10 m.g.d., the increase in sewage flow, due to 100 grinders would be 0.005 per cent. The addition of 500 gal. of sewage to 10 m.g. of sewage is a practical example of the proverbial "drop in the bucket." In similar sense, the increase in sewage solids and organic strength of the sewage will also be a "drop in the bucket."

If 100 families moved into the city of 100,000 population, with their contributing sewage, the city would welcome them and somehow handle the sewage. Why worry, then, about the added waste of 100 families who might desire this new sanitation service in the next few years, and who by their pioneering spirit will pave the way for a new service which a city can render to its good people in the coming years?

Supplementing the above analysis of the unmeasurable effect of 100 grinders on a sewer system and in a sewage treatment plant serving 100,000 persons, the following tabulation gives the estimated effect of units in amounts up to 1,000:

Assumptions: 100,000 population; 20,000 families; 10 m.g.d. sewage flow; solids production per capita in sewage and foodwastes is equal; B.O.D. increase in sewage, due to food wastes, is 15 per cent.

Number of Grinders Connected	Increase in Sewage Flow and Quality			
	Suspended Solids (%)	B.O.D. (%)	Sewage Flow (g.p.d.)	Per Cent of Sewage Flow
100	0.5	0.08	500	0.005
200	1.0	0.17	1,000	0.010
300	1.5	0.25	1,500	0.015
400	2.0	0.33	2,000	0.020
500	2.5	0.40	2,500	0.025
1,000	5.0	0.80	5,000	0.050

Now that we have a clearer concept of the loadings to be imposed on sewer systems and sewage treatment plants by the home disposal of food wastes, it is in order to discuss the way this new material will affect the operation of existing processes. At the same time, it is well to determine what provision will have to be made for the ultimate loading of treatment plants. I believe

we know enough about the basic principles and their practical application to the art of sewer system and sewage treatment plant design and operation to set down the following facts:

1. Solids will not shoal in sewers. Any sewer system or sewage velocity capable of carrying sewage solids will more readily carry food wastes. Compare the heterogeneous nature of sewage solids with the light uniform-sized, flocculent nature of ground food wastes and it becomes evident that the water-carriage system is an ideal method of transporting this new mixed liquid community waste.
2. Mixtures of sewage and foodwastes settle out of suspension and can be clarified.
3. Because of the basic similarity of sewage solids and food wastes, mixtures of normal municipal sewage and food wastes are digestible into a normal sludge with the production of increased quantities of gas of satisfactory quality.
4. Because of the organic solids added to the sewage by food wastes, the biochemical oxygen demand of settled sewage-garbage mixtures, consisting of *all* municipal sewage and *all* municipal garbage, will be higher by possibly 15 to 30 per cent than the oxygen demand of clarified sewage alone.
5. If and when all homes use grinders, the addition of all municipal garbage to sewage would increase the solids load on a treatment plant by an amount depending on the per capita production of garbage and the strength of the sewage flow, but the solids may be approximately doubled.
6. The dual disposal of sewage and foodwastes will result in a large increase in sludge gas production, of typical quality, and increased amounts of sludge fertilizer will be available for use.
7. No problems of treatment are involved which cannot be solved by the same engineering intelligence which is today being applied to sewage and industrial waste treatment.

In discussing the year's research at the New Jersey Agricultural Experimental Station before this association in March, 1938, Dr. Rudolfs indicated that the basic character of sewage is not affected by the addition of foodwastes, the change being of *strength* rather than of *character*, and that the basic processes of sewage treatment are capable of treating mixtures of sewage and ground wastes. Dr. Rudolfs enumerated 17 conclusions which make interesting re-reading at this time to answer the question of the effect of food wastes on sewers and sewage treatment processes.

Economics of Dual Disposal

Little has been written about the economics of dual disposal, because the question has been one of sanitation merit, rather than economic merit. However, the process should have much to endear itself to the economist. Collection is "free" by means of water-carriage, instead of by expensive manual collection and vehicle transportation. It is highly probable that combined disposal will be less costly than separate disposal of sewage and garbage. It is significant that Schroepfer estimated that the increased cost of sewage treatment by chemical precipitation at Minneapolis-St. Paul to handle food wastes would amount to only 55 cents per family per year. Prof. H. E. Babbitt, addressing the 1945 Public Works Congress stated that "In both large and small cities, however, a financial saving can be effected by the introduction of the water-carriage method garbage disposal."

Being a staunch advocate of financing sewage services by means of sewer service charges, I see no reason why we cannot make nominal charges to those homes which desire the use of the sewer system for ground wastes. It must be remembered, however, that the charge should be equitable and based on engineering evaluation of the cost of handling the contributed food-solids, rather than on as such premise as caused municipalities to try to "kill" the bathtub by taxing it out of existence.

Conclusion

We are on the threshold of a new era of sanitation progress. The utilization of sewers for the collection and transportation of dangerous sewage wastes marked the beginning of new health and convenience standards and contributed to the decency and nicety of community life. The utilization of the time-proven water-carriage system for the disposal of the companion waste of municipal life and living, food wastes, should be an achievement in sanitation second only to the adoption of the water carriage method of sewage disposal.

Just as municipal officials viewed the bathtub with alarm and attempted to forestall its use by introducing ridiculous regulatory and prohibitory measures, so we have passed through a period when fears were expressed concerning the overloading of sewers and sewage treatment plants with food wastes. I have little patience or sympathy with the fear that the dual disposal method will overtax existing facilities. It is the function of the sewer system and the sewage treatment plant to handle wastes which can best be disposed of through this public works medium. If the use of these facilities for the dual task of handling two dangerous wastes will contribute to the public good, then it becomes our responsibility to handle these materials in this manner and to provide adequate facilities for doing so. The operator who attempts to delay progress because food wastes would add further headaches to his calling is not a credit to the profession which has learned to accept challenges to its engineering ability to solve intricate problems. Indeed, it would be simpler if sewers did not carry organic materials, just as the early sewers prior to 1815 were limited to the transportation of only storm waters. It would be just as sensible to say, "let us keep sewage solids out of sewers" as it is to say "let us keep food wastes out of sewers." The 130 years which have passed since 1815 have taught us that we are worthy of our salt only if we accept our responsibility to foster public health and public convenience.

If the public wants food waste disposal via the sewer, they will express that desire by buying and installing the mechanical devices necessary for the processing of these foodwastes. If they do, and since we have proven that no unsolvable problems will result from dual disposal, it is our responsibility to accept these wastes as a natural component of sewage flow.

For many years to come, the nominal increase in plant loading can be handled by any treatment plant which now has sufficient "cushion" capacities. Where existing plants are so overloaded that any increment of solids will cause overloading, it is evident that they are in need of natural expansion to handle even sewage. The natural answer is plant enlargement. Where no treatment plants are now in service the installation of food waste grinders will serve to hasten the days when treatment will be provided. The dual disposal process presupposes adequate treatment of the mixed flow.

Engineers who object to dual disposal are missing two important points: (1) They are missing the fact that a sewer system and sewage treatment plant which serves a dual purpose doubles the public service and the prestige of those persons involved in the design, construction and operation of the works; (2) Sewage works which free homes from the drudgery of garbage storage will be further endeared to the public benefited and there will result more favorable public acceptance of the expense of providing facilities for both sewage and food waste disposal.

On these grounds, I rest my prediction that dual disposal is coming and that it behooves the profession to accept it, to foster it and to prepare for it.

GRIT COLLECTION AND CONDITIONING*

By R. C. Merz

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Grit is undoubtedly the most unpredictable material found in sewage, and certainly the most difficult and baffling material the treatment plant operator must handle. There is apparently no "rhyme or reason" to its quantity or quality. It appears when it is least expected and causes many unforseen difficulties in the operation of sewage treatment plants. Even in strictly sanitary sewage systems, grit has been known to wear out sewage and sludge pumps, to clog sludge lines, to build up in channels and to interfere with digestion.

The present trend seems to be toward including some provision for grit collection in virtually all new plant construction, even those serving separate sewer systems. There is not such unanimity, however, in the choice of the ways and means employed to collect and dispose of the grit. The purpose of this paper is to review the fundamentals of grit chamber design and to suggest an economical, proven method of grit collection and conditioning that eliminates the need for elaborate auxiliary equipment.

The nature of grit, in itself, precludes the possibility of designing a channel that can properly handle a wide range in flow, or of building a precision machine that can handle all types and quantities of grit and deliver a product of uniformly good quality. Unfortunately, grit contains varying quantities of heavy or large organic solids that have the same subsiding characteristics as the grit itself. Some of these organics may prove offensive and others not.

*Presented at 18th Annual Meeting, New York State Sewage Works Assn., New York City, on January 18, 1946.

Design Factors

The logical means of simplifying the grit conditioning problem is to design the grit channel or basin in such a way as to allow all the grit to settle out and to minimize the amount of organic material that settles with it. One popular method of achieving this result is to employ a relatively long, narrow, shallow grit chamber, so designed that the velocity through the channel is maintained between 0.75 and 1.25 ft. per sec. at all rates of flow. Any greater speed will result in a carryover of grit to subsequent plant units, and any lesser speed will permit the deposition of too much organic material. The design of the grit channel is directly responsible for the ultimate product obtained.

First, of course, there must be complete data on the flows to be handled. These will include the maximum flow, on which the design is based, and the range, which will determine the number of channels. Seldom, for instance, will a single channel meet the requirements of a municipality served by a combined system. Second, is the decision with regard to the smallest particle to be removed. As will be shown, the smaller the particle to be removed, the larger will be the required channel, and the greater will be the investment. Common practice is to design for the removal of all grit to 50- to 60-mesh, or particles not less than 0.25 mm. (0.008 in.) in diameter. Past experience has indicated that grit finer than this does no great harm when permitted to enter the treatment plant proper. Third, is the decision with regard to the velocity on which the design is to be based. The settling out of the grit is dependent entirely upon reducing the velocity to a value such that the grit will settle

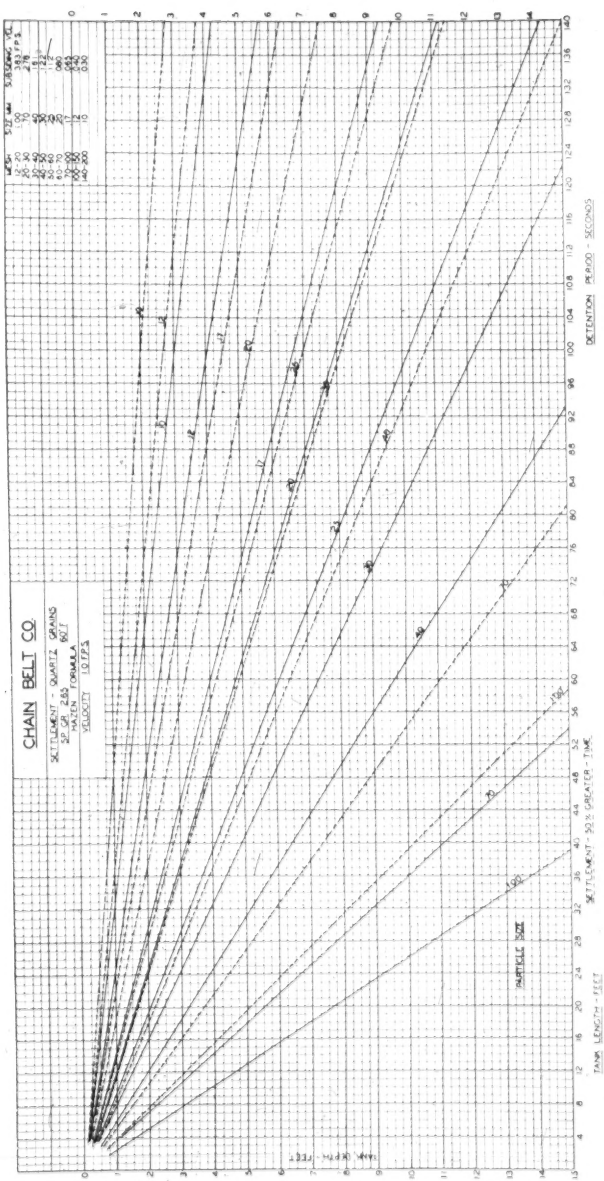

FIGURE 1.—Chart showing rate of settling of quartz sand at velocity of 1 ft. per sec.

while the organics will remain in suspension. It is customary to design for a velocity of 1 ft. per sec. Lastly, there is the subsiding velocity of the grit itself to be considered. We use that of silica sand, which has a specific gravity of 2.65.

Channel Dimensions

All of these factors combine very definitely and their relationship is shown on Figure 1. The diagonal lines represent the path of subsidence of grit particles of various diameters. The diameters, together with their subsiding velocities, are shown in the box in the upper right hand corner. It is important to state here that this chart is based on the assumption that all grit enters the tank at the water surface. That is the only practical premise for the construction of a chart of this nature, in the light of the use to which it is put. Stoke's law and the Hazen formula form the basis for the computations attendant to the plotting of the curves. It is to be noted that the chart shows two sets of curves—one solid, one dotted. The dotted lines represent a factor of safety of 50 per cent, which compensates for irregularities in channel construction, varying specific gravities, varying temperatures, etc. This chart is a handy shortcut to the determination of the channel length, and its use is illustrated by the following example.

Assume a maximum flow of 10 m.g.d. or 15.47 c.f.s., and that it is desired to remove all grit of 60-mesh and larger. With the design velocity in the grit chamber being 1 ft. per sec., it is obvious that the wetted cross-sectional area of the proposed channel must be approximately 15.47 sq. ft. If an arbitrary channel width of 5 ft. is assumed, the maximum effective water depth would therefore be 15.5 divided by 5, or 3.1 ft. Now the chart may be used for determining the channel length, which must be sufficient to allow time for the grit particle to settle to the bottom before it reaches the outlet end of the channel.

In this case, notice that a quartz particle 0.25 mm. in diameter settles at a rate of 0.112 ft. per sec. Since the water depth in the channel is 3.1 ft., it would take the particle 3.1 divided by 0.112, or 29 sec. to settle to the bottom. Since the sewage is flowing through the channel at a velocity of 1 ft. per sec., the channel would therefore have to be 29 ft. long. This tank length can be found directly from the chart simply by following the 3.1-ft. depth line horizontally to its intersection with the 0.25-mm. diameter particle subsidence line, and noting the required length from the corresponding point along the bottom of the chart. This is found to give a channel length of 30 ft., which agrees substantially with the calculation. Allowing for the factor of safety, the length should be 44 ft. Note the rapid increase in channel length, accompanied by an increase in equipment cost, for the removal of finer grit. To remove grit of 60- to 70-mesh in size, a channel 38 ft. minimum to 57 ft. maximum in length must be provided. To remove 70- to 100-mesh grit, the range in length is 46 ft. to 68 ft. The shorter channel can be maintained by using a greater width, thus decreasing the effective water depth but, again, this means an increase in the equipment cost.

Velocity Control

A grit chamber is thus theoretically designed to remove particles above a certain size at a predetermined sewage depth and velocity. While a constant flow cannot be maintained, it is possible to maintain a velocity reasonably close to the desired value of 1 ft. per sec., and it is extremely important that this be done. There are two principal velocity controlling devices in general use—the proportional weir and the Parshall flume.

A proportional weir is actually a combination weir and orifice, designed

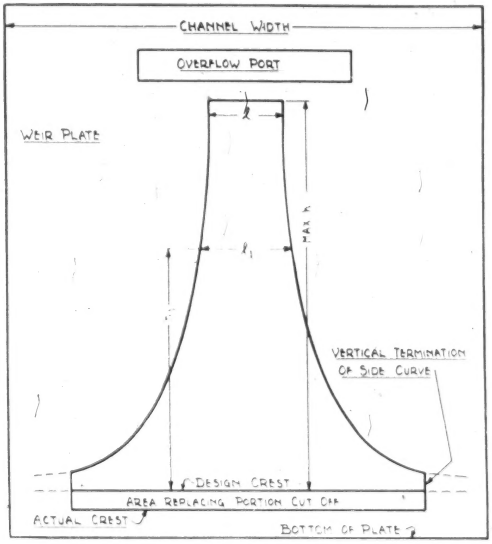

FIGURE 2.—Design elements of a proportional weir.

to keep the discharge proportional to the head. This is accomplished by constructing the weir with curved sides, as shown in Figure 2.

Many authorities have advanced formulae for computing the rate of flow through a proportional weir, all derived by calculus and all giving similar results. Formulae appeared as early as 1914 in the June 25 and August 27 issues of *Engineering News-Record*. The expression $Q = 7.55 \quad (l/h)h$, wherein Q is expressed in terms of cubic feet per second and l and h are expressed in feet, is the simplest of the several formulae. This equation is particularly convenient to use because, within practical limits, it can be adapted to channels of irregular cross-sections.

The Parshall flume (Figure 3) is another device sometimes used for the control of grit chamber velocity within moderate limits and with a moderate range of flow. More often, however, it is used as a means of measuring the flow with an accuracy comparable to any of the standard forms of weirs. Although it takes up much more space than does the proportional weir, it has the advantage that it will withstand a high degree of submergence (70%) without affecting the rate of free-flow discharge. This means that there is not as much head required when using the Parshall flume as when using the proportional weir. The proportional weir must have free discharge, that is, no submergence, at all times, which means that the total head loss to be provided must be equal to the effective water depth of the grit chamber. In actual practice, free-flow is provided between the minimum and maximum ranges, and little concern is given flows below the average minimum when hydraulic conditions are unstable. It should be remembered that this type of control section cannot maintain a uniform velocity over a wide range in flow.

For instance, with a range in flow of 5:1, the minimum velocity will be approximately 60 per cent of the maximum, but this is quite satisfactory for most applications.

The dimensions of Parshall flumes of various capacities are given in Bulletin 1683 of the U. S. Department of Agriculture, which bulletin is entitled "Measuring Water in Irrigation Channels."

Quality of Grit

If all grit and organics did actually enter the grit chamber at the water surface and if the flow remained constant, a relatively clean grit would be obtained from the grit chamber. Unfortunately, those two desirable conditions are never found in practice.

Figure 4 illustrates what actually takes place within the grit chamber. The ideal condition is shown in the top section. All grit and organics are entering the chamber at the surface, grit is being trapped within the confines of the chamber, and all organics are passing on through the channel.

Actually, the grit is distributed throughout the sewage, as are the organics, and the conditions are undoubtedly closer to those illustrated by the center section. Here, the grit is more certain to be trapped, but so are some of the organics for they have less distance to settle and will strike bottom before they reach the chamber exit.

The worst condition is indicated by the bottom section, which illustrates low flow conditions when the water

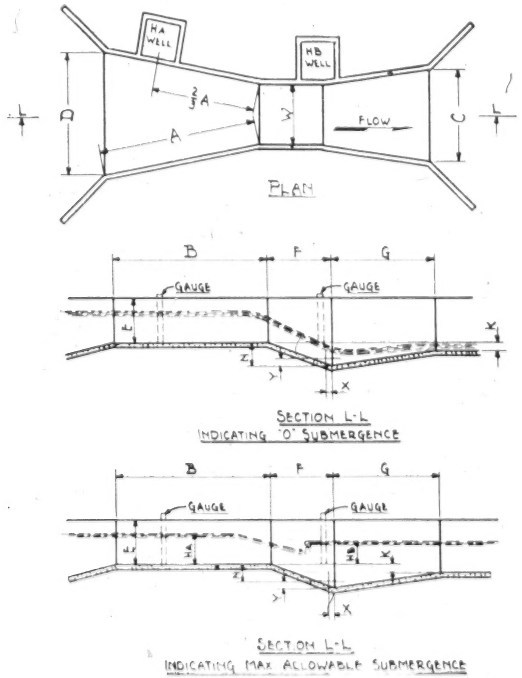

FIGURE 3.—Design elements of a Parshall flume.

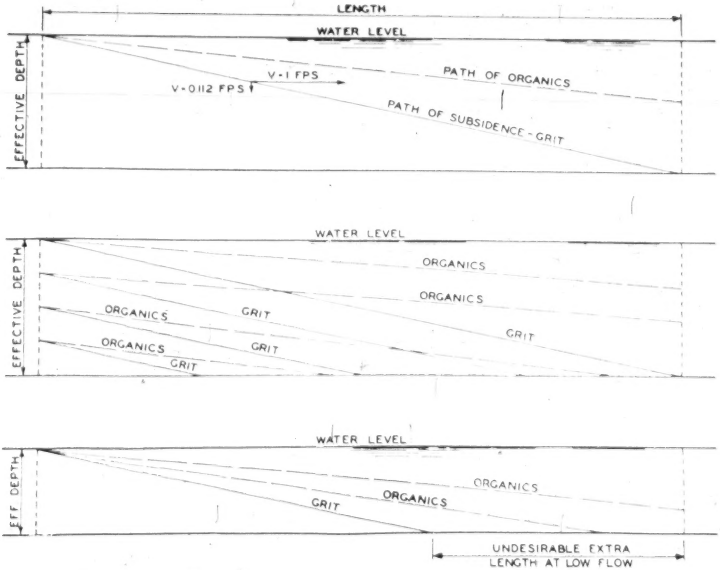

FIGURE 4.—Gravimetric separation of grit and organic matter in a grit chamber.

depth is actually considerably less. Here, even though the velocity is still 1 ft. per sec., and even though all grit and organics should enter at the surface, large quantities of organics will be trapped since, as is evident from the sketch, the chamber is then too long. Most operators will have seen grit heavily loaded with organics being brought up by the equipment when it is first operated in the morning, the result of a decrease in water depth during night flows.

Particles which do settle to the bottom may be picked up again by the flow, providing they have not been buried by additional grit depositing on top of them. This starting of particles in motion along the bottom, known as scour, has been excellently covered by Camp (1). The importance of scour is recognized and the design velocity herein recommended lies within the range prescribed by Camp.

Organic Limits

From a study of Figure 4, it is evident that a pure grit, free from organic material, cannot be obtained from a grit chamber, no matter how carefully it may be designed. The question is, how clean must the grit be to allow convenient disposal without nuisance and how shall the grit be conditioned to remove the objectionable organic material?

Practically the only acceptable test for ascertaining the nuisance value of grit is the Dazey churn test which is, in itself, a very inconclusive determination. Actually the Dazey churn test measures the amount of *free* organic material in the grit and expresses the amount as a per cent of the entire mass. Large organic solids can be in the grit, however, and not be correctly reflected in the test results. For example, quantities of angle worms might be present in the grit samples, which worms would

not be siphoned off in the Dazey churn test and therefore theoretically would not contribute to the putrescibility of the grit. Further, large quantities of non-putrescible organics might be left within the churn after washing, and cause a false increase in the putrescibility reading.

It is generally accepted that a grit of less than 5 per cent putrescibility is satisfactory for ordinary disposal although some specifications call for a putrescibility of less than 1 per cent. It has been our experience that any grit, no matter how carefully conditioned, is far from being beach sand. The difference between a grit of 1 per cent and 3 per cent putrescibility is not readily discernible by sight or smell, and the need for removing that extra 2 or 3 per cent is very questionable, particularly from the economical viewpoint.

Grit Conditioning

Several types of grit washers are available and, with proper operation and maintenance, they can be made to deliver a grit containing less than 1 per cent putrescible matter. But grit is very abrasive and difficult to handle, with the result that maintenance of such equipment is likely to be expensive. It is suggested that this equipment be reserved for the most exacting jobs and that grit conditioning by recirculation be substituted as a means of obtaining a satisfactory product for most requirements.

As shown previously, organics are present in grit because some of this material enters the channel near the bottom, and accumulates during low flow when the grit channel is out of proportion between length and water depth. Recirculation is merely a means for returning the grit to the channel when settling conditions are optimum, thus allowing the grit to resettle and the organics to flow on out of the channel.

Figure 5 illustrates a conventional chain and bucket grit collector designed for grit recirculation. The equipment consists of two strands of chain on which V-buckets are mounted at regular intervals. In operation the buckets travel along the tank bottom toward the influent end at which point they travel upward and over the headshaft where they discharge the grit into the grit can. Between the V-buckets are mounted agitating scrapers which stir up the grit and release organics to the flow just prior to its collection by the buckets. Except under peak storm conditions, the grit equipment is operated only once or twice a day for short periods.

Assume that during the night, at low flow, a considerable amount of organic material has settled in the channel with the grit. When the operator comes on duty in the morning he schedules his work so that he operates the grit equipment at that time when the sewage flow is near its daily peak. He

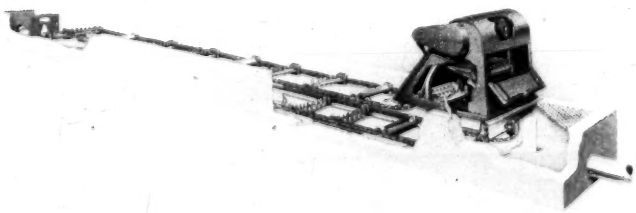

FIGURE 5.—Conventional chain and bucket grit collector designed for grit recirculation.

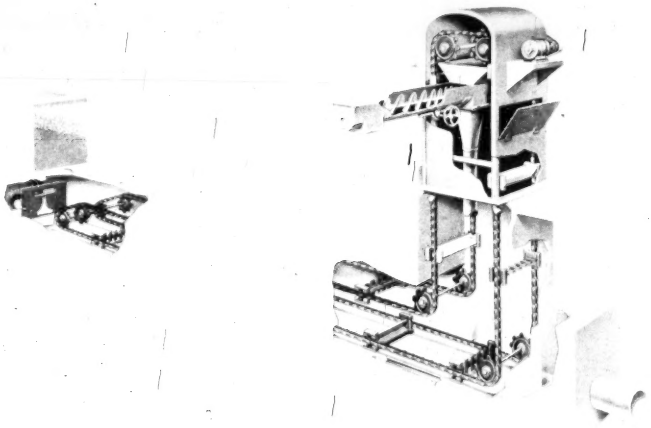

FIGURE 6.—Grit collector equipped with screw conveyor designed for recirculation of grit.

starts the conveyer and removes the grit can from beneath the discharge chute. As the grit is dumped from the buckets it falls through a hole in the floor and back into the channel—*at the water surface*. In other words, the ideal condition discussed previously has been created. The grit is allowed to resettle and the organics to flow on through the chamber. By observation or from experience the operator can tell when recirculation has had its effect and when the grit is clean enough to be suitable for disposal. He then replaces the grit can and catches the cleaned grit for final removal and disposal. No auxiliary conditioning equipment is required.

A more elaborate arrangement of equipment is shown in Figure 6. It is primarily for deep channels and where it is desirable to provide grit storage within the housing, as well as periodic automatic discharge to the vehicle which is to cart it away. The scheme of operation is the same as that described for the equipment shown in Figure 5. To afford recirculation it is only necessary to open the slide gate in the screw conveyor trough by means of the rack and pinion shown and the grit will be returned to the flow, at the water surface.

If conditions are such that separate washing equipment is mandatory, provision for recirculation is recommended since by its use the load on the washer will be greatly relieved.

The principle of recirculation is not restricted to any particular type of equipment. It is felt that there are many rectangular grit chambers in existence of approximately proper design from a hydraulic standpoint, the performance of which could be measurably improved by the incorporation of recirculation and by placing a velocity control device in the chamber.

Racine, Wis., Results

Among the installations in which recirculation has been used and studied is the Racine, Wis., sewage treatment plant (2). The grit chamber equipment installed here in 1938 consists of four chain and bucket type grit col-

lectors, each approximately 10 ft. wide, with all four units discharging into a common cross-screw conveyor which, in turn, discharges into a separate washer. The tanks originally were laid out for a totally different type of equipment and it was necessary to adapt the chain and bucket type equipment to them. The resulting hydraulic characteristics of the chambers were not entirely satisfactory. The material brought up by the buckets was offensive and almost always very dilute, putting an extremely heavy load on the washer.

The reason for the continuous removal of a dilute and offensive grit is evident when it is considered that these channels should have been handling an average of 32 m.g.d. to fulfill design standards, but actually were handling an average of only 10.5 m.g.d.

Early tests showed grit putrescibility values of from 6 to 14.5 per cent, the average being 8.5 per cent. The dry weight of the grit averaged 27.4 lb. per cu. ft. Steps were immediately taken to change this condition by the construction of division walls as required between collector units, so that the operator had more flexibility and so that a flow of 16 m.g.d. would almost meet design requirements. Most important of all, the recirculation feature was added. This was accomplished by extending the cross-screw conveyor in the opposite direction to the direction of discharge. An extension of only a few feet was required to bring the discharge point over the inlet chamber. Reversal of the screw was, of course, provided for. Simply by reversing the screw conveyor, it was then automatically possible to return all grit to the influent—at the top—for resettling.

As the operating personnel became familiar with the control of the equipment, a grit of a very much cleaner nature was removed. The putrescibility value has steadily decreased to where it is now consistently between 1 and 2 per cent.

During the first year of operation with recirculation, the average dry weight of the grit increased to 30.7 lb. per cu. ft. and by 1945 had increased to 37 lb. per cu. ft., a gain of 35 per cent. Similarly, during the first year of recirculation, the average putrescibility content decreased to 2.8 per cent and by 1945 had decreased to 1.3 per cent, an overall improvement of 85 per cent.

The Racine results summarized briefly here are reported in detail by Hay (2). There are at present eighteen other installations in which grit conditioning by recirculation is practiced; all report satisfactory results in the production of a quality of grit that amply meets disposal requirements. In all cases, the mid-morning hours have been found to be the best time for the recirculation operation, because peak rates of flow then prevail and afford the depth necessary for organic particles to clear the chamber.

Summary

This paper represents an endeavor to list the factors involved in grit removal and conditioning, together with the provisions that should be made for them if satisfactory results are to be achieved. The grit chamber channel must be designed on the basis of sound hydraulic principles; there should be suitable means for controlling velocities; and equipment should be selected that will afford the utmost in operation flexibility. Even when these basic elements are incorporated into the facilities, the production of grit suitable for disposal depends finally upon the attention and care that is forthcoming from the operator.

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2. Hay, Thomas T., "Experience in Grit Removal and Handling at Racine, Wis." *This Journal*, **18**, 54 (Jan., 1946).

PROGRESSIVE DEVELOPMENT OF DISTRICT 2 SEWAGE WORKS, TONAWANDA, N.Y.*

By Channel Samson

Superintendent of Sewage Treatment

The history of the District 2 sewage treatment plant of the town of Tonawanda follows very closely the improvements in the art of sewage treatment which have occurred during the past twenty years. From this standpoint the plant is particularly interesting.

Development of Plant

The first plant was designed in 1922 and built in 1923. It included two circular Imhoff tanks of the radial flow type with open sludge beds designed to give an area 0.25 sq. ft. per person. The effluent passed to the Niagara River through an outfall sewer about a mile long. The plant capacity was about 10,000 population based on a per capita flow of 100 g.p.d.

In 1929, two additional Imhoff tanks were constructed and glass-covered sludge beds designed on a basis of 0.5 sq. ft. per person were installed. Changes were made in the baffles and in the proportioning of sludge storage and settling compartments of the Imhoff tanks. The 1929 extensions were rated at 12,000 population, making a total plant capacity of 22,000 persons. No screen chamber or distribution chamber had previously been included in the plant and these needed facilities were now also built, a hand raked bar screen being provided. A centrifugal sludge pump was installed.

This plant worked well except for disruptions caused by excessive infiltration and storm water which at times overloaded the tanks to the extent that they overflowed their walls.

The population in the district increased rapidly during the period from 1925 to 1930. In 1930 an engineering report recommended certain improvements and additions. Shortly thereafter a by-pass was constructed around the plant to protect the Imhoff tanks from flooding, an improved screen chamber was constructed, chlorination equipment was added for post-chlorination, and facilities for flow measurement were installed. A building was provided to house these facilities. The engineering report recommended the enlargement of the sludge digestion and storage facilities, but this work was not then done.

In 1936 studies were made on pre-chlorination and as a result the chlorination facilities were altered so that they could be used for pre- or post-chlorination as well as for separate disinfection of storm flows. This arrangement resulted in better odor control, a saving in the use of chlorine and an improved plant effluent. A separate water system was installed to pump sewage effluent for use in the chlorinators, which made possible marked saving as the water rates were rather high.

When the PWA made grants available toward the construction of municipal improvements, the town decided to install the digestion capacity previously recommended and to make certain other improvements. By this time the population tributary to the plant was estimated to be about 35,000 persons and the sewage flow was averaging over 3 m.g.d.

Plans were prepared for two digesters, each having a capacity of 70,000 cu. ft. A sludge pumping station, sludge gas collection facilities, new chlorination and cylinder storage equipment, laboratory, and office were

* Presented at meeting of Western Section, New York State Sewage Works Assn., held at Kenmore, N. Y. on April 28, 1945.

FIGURE 1.—General view of District 2 sewage treatment plant, Tonawanda, N. Y.

all provided in a new building. The digesters were equipped with sludge and scum stirring mechanisms made by the Hardinge Company. The chlorinators are connected with ton containers stored on the floor below. The gas equipment included a pressure storage tank.

The Imhoff tanks were converted into sedimentation tanks by removing the baffles between the sludge storage and sedimentation compartments. Sludge collection mechanisms were installed in each tank. The total depth is about 30 ft., but the effective depth for sedimentation is considered about 13 ft.

A new grit chamber was provided with a chamber to permit the installation of two comminutors. Only one was installed, a bar screen being placed in the other channel.

These improvements and additions were all placed in service before 1940. Operating experience soon showed that there was too little available sludge drying space, and that the digesters were too small to act both as active digesters and as storage tanks to carry the sludge which could not be discharged to the inadequate drying beds during the winter months. In emergencies, to prevent upsetting the digesters, considerable amounts of sludge were lagooned. Trouble was also experienced with the operation of the sludge pumps in pumping the very thick digested sludge.

Recent Extensions

In 1942 plans were made for additions to the sludge digestion capacity and sludge drying facilities. The town desired to install vacuum filters for sludge dewatering. Due to war conditions these were denied, but priorities were finally made available for constructing two digesters and open sludge drying beds which, together with all existing units, would rate the plant at about 70,000 persons capacity. The new facilities included two digesters, with a combined capacity of 70,000 cu. ft., one new duplex plunger sludge pump, a new heating boiler and about 14,500 sq. ft. of open sludge beds. A second comminutor was also installed.

The new digesters are 45 ft. in diameter and have a side water depth of 22 ft. 6 in. They are equipped with sludge and scum stirring mechanisms

as furnished by the Ralph B. Carter Co. The drive has two speeds and the mechanism is entirely supported from the roof beams. The exposed drive mechanism is enclosed in a weatherproof case. The mechanism has two features which particularly appeal to the operators: a shear pin in a flexible coupling which protects the mechanism from undue strain and an alarm device connected with the oil pressure system which not only sets off an alarm when the pressure drops, but also stops the mechanism.

The masonry above grade is encased with a 4-in. brick veneer. The roof is covered with a wooden shell upon which is applied 1 in. of celotex insulation surfaced with tar and gravel.

The building between the digesters, which houses the sludge pumps and new gas boiler, is excavated to the same elevation as the bottom of the digesters, which is about 16 ft. lower than the floor level at which the sludge pumps were formerly located. At this lower elevation the pumps when pumping from the primary sedimentation tanks have a positive head on the suction line, and give no difficulty in pumping. Previously when the sludge was heavy, it could not be pumped from the higher elevation without dilution with sewage or flushing the line. There are now three sludge pumps in all.

Complete flexibility of piping has been secured so that any one of the three sludge pumps can pump to any one of the four digesters from any one of the four sedimentation tanks. Digested sludge can be discharged from the digesters to the sludge beds by gravity or it can be pumped.

An unusual feature of the digesters is the arrangement of the sampling piping and the sampling sinks. The

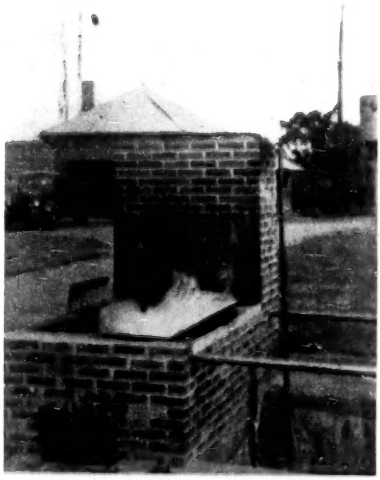

FIGURE 2.—Scum and screenings incinerator, District 2 sewage treatment plant, Tonawanda, N. Y.

FIGURE 3.—Belt loader used for handling sludge removed at drying beds.

piping is so spaced that samples may be withdrawn at 2-ft. intervals for the entire height of the digester. The waste material is run into a concrete cast-in-place sink, which is built like an inverted hood. It is deep enough so that no splashing reaches beyond the sink, and any kind of a container can be placed under the sampling outlet. A flushing outlet is adjacent to supply water for washing and the thermometer showing the temperature inside the digester is nearby.

The new sludge beds are designed and built similarly to the glass-covered sludge beds. A completely graded sand bed is provided. The underdrainage system includes a center drainage channel made of two-piece tile blocks, to which the bottom of the bed slopes on each side. The ground material is hard clay. The slopes were cut to grade, and in some cases cement was worked into the surface. Concrete tracks to support a truck are constructed on top of the sand bed. Freeboard is sufficient to permit a 12-in. depth of sludge to be flowed onto the beds.

A motor operated belt loader (Figure 3) is used for the loading of dried sludge from the beds to the removal truck. A device has been provided so that the truck pulls the loader behind it. The operation of these beds in dry weather has been most satisfactory and the operators now prefer the sludge loader to the bucket and overhead runway provided at the glass-covered units.

These improvements were all completed in 1943. In 1944 two more improvements were made a small incinerator for screenings and scum and the insulation of the exposed parts of the original digesters. Brick veneer was used to enclose the walls and roofs such as used on the new digesters were provided.

Costs

Year	*Project*	*Cost*
1923	Original plant	$ 52,000
1927	Two additional Imhoff tanks and sludge beds	75,500
1930-33	By-pass, chlorination, etc.	10,000
1934	Chlorination improvements and water supply	1,500
1939	Sludge digesters, remodel Imhoff tanks, etc.	95,000
1943	Two additional digesters, sludge beds, etc.	111,000
1944	Incinerator and insulation of original digesters	6,000
	Total construction cost	$351,000

The above total represents the cost the present primary treatment plant

with a capacity of 70,000 persons. In the light of current prices, the cost of $5.00 per capita is very favorable.

Operation Observations

Digesters

In the operation of the digesters, the temperatures were compared in those which were insulated and those which were not. It was found that 4,000 g.p.d. of additional circulating water were required to maintain the same temperatures in an uninsulated digester as is held in the insulated digesters. For two digesters this would mean 8,000 g.p.d. and for an entire heating season of 5 months, over 1,000,000 gal. While the heat values were not calculated, nor the extra amount of gas required, it was considered that the insulation of the two original tanks was more than justified.

During the past season, this plant has operated entirely on sludge gas for fuel to heat the various buildings and to keep the four digesters at 80° F. or better at all times. There were times, however, when the margin was close, and if all tanks had not been insulated it is probable that some purchased gas would have been required.

The new digester stirring mechanisms make one revolution in 12 min. at low speed. The first installation revolved in 3 min. less time. It was observed that the faster stirring produced a 1 per cent better reduction of moisture and volatile matter in the sludge. There seems to be little difference in the temperatures in the various digesters due to variations in the stirring rates. The faster stirring rate of approximately one revolution in 6 min. has not yet been used, but it is expected that this will create a still further reduction in moisture and volatile matter. Therefore, it is proposed to use this faster rate at any time when the sludge drying facilities are crowded and when a shorter period of digestion seems necessary.

Sludge Drying Beds

Comparisons were made in the drying time required at the open and glass-covered drying beds for the same depths of sludge under the same weather conditions and for the same quality of sludge. The time selected was the summer season of May to October. Sludge was drawn from the same digester to any pair of beds being compared, the depth of drawing being carefully measured at 10 in. The average drying time at the open beds was 6 days as compared to 12 days for the enclosed beds. During the hottest weather in the summer, the drying time at the enclosed beds dropped to a minimum of 10 days, but during the early spring and late fall it was as high as 20 days.

During the summer, the open beds are used to their maximum capacity and the sludge levels in the digestion tanks are lowered sufficiently to provide storage to carry over the four winter months. In the winter the covered beds are used to their maximum capacity, but with sustained weather below freezing such as occurred this year from December 1 to February 15, not much dried sludge fit to handle is produced. By skillful manipulation it was not necessary to lagoon any sludge, however, some emergency measures were taken. The sludge placed on the covered beds in December was still not dry in March, so 160 tons of partially dried sludge was moved over to the open beds on March 12. About 9,000 cu. ft. of wet sludge (11.2 per cent solids) was drawn to the covered beds on March 19, and 10,200 cu. ft. was drawn to the open beds on April 9 after the sludge from the covered beds had dried and was removed.

Scum and Screenings Incineration

One of the troublesome operation features in this plant has been the accumulation of grease and scum at the digesters. To minimize this the oper-

ators in recent years have removed the skimmings from the primary tanks to a scum well, and then removed the grease and scum manually to a remote point where it was buried or burned.

To eliminate the transportation and extra labor and to dispose of the material without nuisance, a small incinerator was built along side the scum well (Figure 3). A gas line from the sludge waste gas line provided auxiliary fuel. The material to be burned is now removed from the scum well, placed on the incinerator grate, the sludge gas line is lit and then the material proceeds to burn. After it has ignited sufficiently it is no longer necessary to use the gas if one must economize on its use. Approximately 60 cu. ft. of scum and grease are burned per week, or about 3,000 cu. ft. per year. Whereas in days past several feet of grease and scum would collect in the digesters during the past sixteen months there has not been over 4 in. at any time.

An unusual condition occasionally occurs when about 300 cu. ft. of grease and scum will collect in a period of a day or two when wastes are discharged from a local industrial plant. At such times a man is assigned to handle the material, and it is all burned without detriment to operation of the plant.

In dry weather it is possible to burn some of the screenings, but in wet weather there is not enough heat available in the furnace.

A CORRECTION

Thomas R. Camp, author of the article "Design of Sewers to Facilitate Flow," published in the January, 1946, issue of THIS JOURNAL (Vol. 18, No. 1, page 3), directs attention to an error in one of the equations presented therein.

A square root sign was omitted in the equation appearing at the bottom of the right hand column on page 6. This equation should read:

$$\frac{n}{n_{\text{full}}} = \left(\frac{R}{R_{\text{full}}}\right)^{1.6} \sqrt{\frac{f}{f_{\text{full}}}}$$

Industrial Wastes

TREATMENT OF CYANIDE AND ACID PLATING WASTES

By Nicholas Herda

Utilities Superintendent, Kaiser-Frazer Corp., Willow Run, Mich.

To prevent the pollution of the Huron River by toxic substances contained in industrial wastes resulting from cleaning, plating and alroking * operations, special treatment facilities were installed in October, 1942, at the Willow Run Bomber Plant (now engaged by the Kaiser-Frazer Corp. in the manufacture of automobiles).

The wastes include waters containing sodium cyanide, chromic acid, dichromates, hydrochloric acid, nitric acid and zinc sulfate. The volume required to be handled amounts to about 8,000,000 gal. per month or 300,000 g.p.d.

Treatment Plant

A diagrammatic layout of the waste treatment plant is shown in Figure 1. The plant comprises two flash mixers; equipment for feeding lime, ferrous sulfate and sulfuric acid; two flocculators; six sedimentation tanks of 14,600 gal. capacity each, equipped with mechanical sludge collectors and arranged so that any two units can be used separately, if desired; three sealed 27,000-gal. reaction tanks (for cyanide wastes), lined with acid-resistant materials and equipped with aeration piping and blowers exhausting through stacks 40 ft. high (Figure 3); and complete appurtenances in the way of waste and sludge pumps, chemical storage facilities, air compressors, etc.

Separate sewers, constructed of noncorrosive and acid-resistant materials, are used to conduct the acid and cyanide wastes to the treatment plant. This dual system is essential because hydrocyanic acid fumes, a most deadly gas, would be formed if the acid wastes and cyanide wastes were combined and mixed in a common sewer.

The treatment procedure is varied to suit the particular wastes received. When a batch of waste is to be dumped in the plating department, the operator at the waste treatment plant is notified by telephone of the type and quantity of wastes and the time they will be discharged. He then proceeds to arrange for the proper routing and treatment.

Treatment of Acid Wastes

HCl, H_2SO_4 and HNO_3 Solutions

The acid solutions are routed directly to the flash mixers, where they are dosed with lime. From there the flow is to the flocculators where precipitation of $CaSO_4$ occurs. The precipitate is removed at the sedimentation tanks and the sludge pumped to a lagoon located approximately a mile distant.

The required dosage of lime is computed from preliminary determinations of the acidity of the wastes.

Chromic Acid Solutions

When chromate and dichromate wastes are received, ferrous sulfate is used to reduce the chromium to sulfate and lime is added to neutralize the

* A process used in the oxidation of aluminum rivets. The aluminum is first etched with 10 per cent chromic and sulfuric acids, then rinsed and immersed in a solution of sodium dichromate and sodium carbonate. After another rinsing, the aluminum is dipped in a solution of sodium dichromate at 150° F.

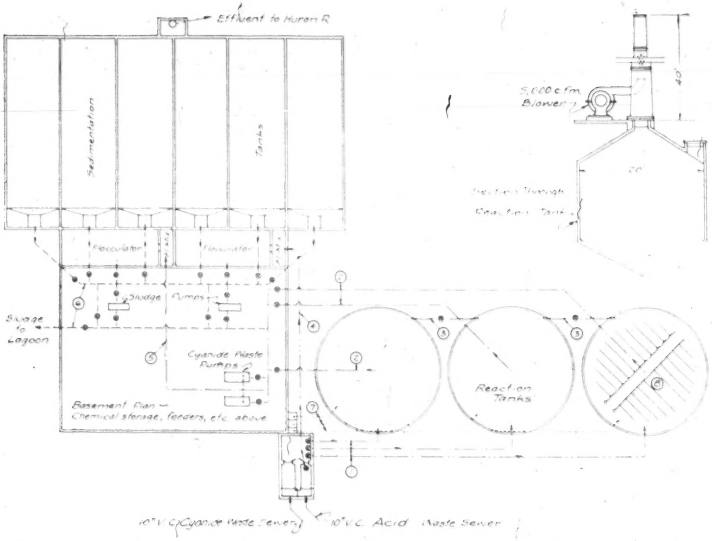

FIGURE 1.—Diagrammatic layout of treatment plant for cyanide and acid plating wastes at the Kaiser-Fraser Corp., Willow Run, Mich. Piping key: (1) 6-in. discharge lines to reaction tanks; (2) suction lines to cyanide waste pumps; (3) reaction tank equalizing piping; (4) 10-in. C.I. direct discharge to No. 1 flash mixer; (5) cyanide waste pump discharge to No. 2 flash mixer; (6) sludge piping; (7) 1½-in. H_2SO_4 feed lines to reaction tanks; (8) Duriron air distribution system in all reaction tanks.

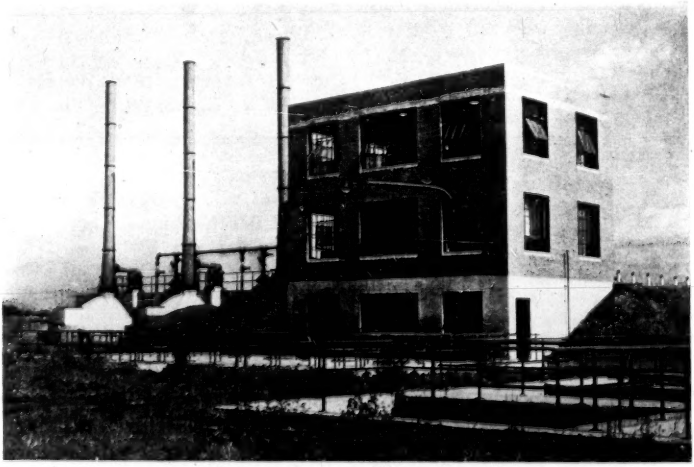

FIGURE 2.—Exterior view of cyanide and acid plating wastes treatment plant, Kaiser-Frazer Corp., Willow Run, Mich.

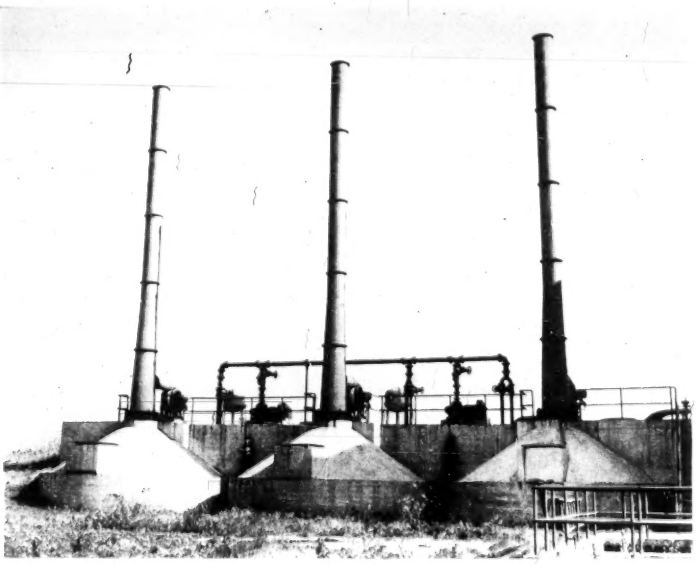

FIGURE 3.—Reaction tanks, showing blowers and stacks.

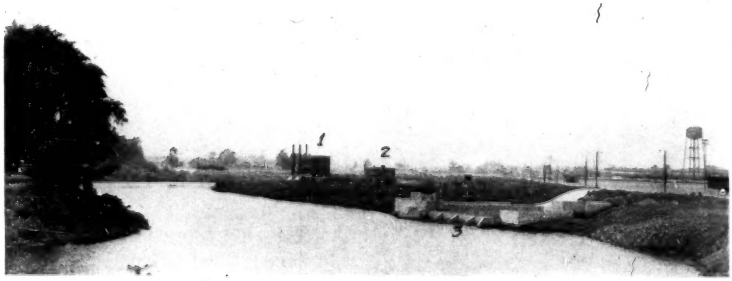

FIGURE 4.—Waste treatment facilities serving the Kaiser-Frazer Corp. plant at Willow Run, Mich.: (1) Cyanide and acid plating wastes treatment plant; (2) Sewage treatment plant; (3) Gale oil separator receiving wastes from machine shops, press rooms, etc.

acid and precipitate the heavy metals. The treatment flow sheet is the same as for the other acid wastes described above except that the concentrated chromic acid wastes are collected and stored in one or two of the reaction tanks until they can be sampled and tested as the basis for computation of chemical dosages. The weaker chromic acid rinse waters are not collected and stored in this manner, but are routed directly to the flash mixers.

The required dosage of $FeSO_4$ is determined from preliminary tests of the waste. The following test procedure is employed: (a) measure accurately

100 ml. of waste into a 300-ml. Erlenmeyer flask; (b) add 2 ml. H_2SO_4 and 10 ml. of 0.01 N $FeSO_4$ and mix well by rotating flask;* (c) allow to stand 5 min. and titrate with 0.01 N $KMnO_4$ solution until one drop of $KMnO_4$ yields a faint color that will remain at least 10 sec. The parts per million of CrO_3 (chromic anhydride) contained in the sample is calculated by deducting the ml. $FeSO_4$ solution and from the ml. $KNmO_4$ solution added and multiplying the difference by 3.26 (for 100-ml. sample). For example, if 10 ml. of 0.01 N $FeSO_4$ is added to the sample, and 6 ml. of 0.01 N $KMnO_4$ is used in titration, the CrO_3 content of the sample equals 3.26 (10–6) or 13.04 p.p.m.

Five p.p.m. of $FeSO_4$ is applied per 1 p.p.m. of CrO_3 in the treatment of this waste. Hourly analyses are made of the plant influent and effluent to maintain complete control of the effectiveness of the treatment.

Table 1 includes typical data on a dumping of chromic acid wastes, together with the quantities and rates of application of chemicals used in treatment. The effluent resulting from the treatment of this batch had a CrO_3 content of 5.0 p.p.m. and a pH of 8.

TABLE 1.—Treatment Data on Typical Batch of Chromic Acid Wastes. Kaiser-Frazer Corp., Willow Run, Mich.

	Reaction Tank 1	Reaction Tank 2
Quantity of waste (gal.)	27,415	25,847
pH	2.8	2.7
CrO_3 content (p.p.m.)	473	470
CrO_3 content (lb.)	108	107.5
$FeSO_4$ required (lb.)	907	903
$FeSO_4$ dosage (lb. per hr.)	413	437
H_2SO_4 content (p.p.m.)	1,372	1,294
H_2SO_4 content (lb.)	314	296
Lime required (lb.)	454	452
Lime dosage (lb. per hr.)	207	218

Treatment of Cyanide Wastes

The cyanide wastes are always routed directly to the sealed reaction tanks. The cyanide content is then determined and the proper dosage of H_2SO_4 is calculated and added. Then the acid-treated wastes are aerated vigorously while the fumes are forcibly exhausted at the stack by compressed air at the rate of 5,000 c.f.m. In this fashion the poisonous hydrocyanic acid fumes are discharged to the atmosphere in a very dilute concentration. If the wastes are excessively acid after removal of the cyanide, they are routed through the remainder of the plant for neutralization with lime.

Cyanide concentrations above 50 p.p.m. in the wastes are determined by accurately measuring 100 ml. of sample in a volumetric flask and filtering into a 300-ml. Erlenmeyer flask. Two ml. of 10 per cent potassium iodide and 5 ml. of ammonium hydroxide are added and mixed by rotating the flask. The treated sample is titrated immediately with 0.1 N silver nitrate solution, added drop by drop until the first permanent yellow color obtains. The CN content in p.p.m. is calculated by multiplying the number of ml. of 0.1 N silver nitrate solution required in titration by 52.03. For CN concentrations of 5 to 50 p.p.m. the procedure is identical except that 0.01 N silver nitrate solution is used with a calculation factor of 5.203. Likewise, samples containing less than 5 p.p.m. are titrated with 0.001 N silver nitrate solution and a factor of 0.5203 is used.

The concentrated cyanide wastes dumped in batches at the plating rooms average about 600,000 gal. per month and contain about 75 p.p.m. CN. These wastes are about pH 10 as received for treatment. The rinse waters carrying cyanide usually contain about 2 p.p.m. CN. Approximately 14 lb. of H_2SO_4 per pound of CN is applied at the reaction tanks, reducing the pH to 3, after which the acidified wastes are aerated for 6 to 10 hr. Complete treatment, including neutralizing, produces an effluent containing about 1 p.p.m. of cyanide and having a pH of about 7.5.

* If waste is weak use only 5 ml. of 0.01N $FeSO_4$; if strong, use 20 ml. or more.

A REPORT OF PROCEDURE FOR THE HANDLING OF INDUSTRIAL WASTES

PREPARED BY THE 1945 COMMITTEE ON INDUSTRIAL WASTES OF THE CALIFORNIA SEWAGE WORKS ASSOCIATION

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* Deceased.

The basis of origin of this report is contained in the report of the Policy Sub-Committee of the Industrial Wastes Committee of the California Sewage Works Association, which recommended:

"That a report on the policy and problems involved in the disposal of liquid industrial wastes be prepared with a view to submitting it to six agencies discussed herein to the end that cities and industries of the State of California may cooperate to the advantage of all concerned."

The sub-committee recommended that the six parties interested in this problem were as follows:

1. Management of industries
2. Operators of sewage treatment plants

3. Sanitary engineers and consultants
4. Local government agencies
5. Chambers of commerce
6. State agencies

and they suggested that the report be divided into chapters or sections corresponding to the above interests.

With slight changes of nomenclature and order this has been adhered to in the report which follows.

Introduction

For years, municipalities have permitted the discharge of industrial wastes into their sewer and storm drain systems, with little or no regard to the possibility of menace to the public health and safety, potential damage to the system, or increased costs of maintenance and operation.

In fact, many cities have offered such disposal facilities in their endeavor to induce industrial plants to establish and build in their cities, without having any knowledge of the volume, character, or possible effect of the industrial wastes upon their sewers and drains, or upon operation of sewage treatment plants. In many cases where such offers have been accepted, the results have been serious, both to the community and to the industry affected.

Industries have, in their turn, failed to recognize the possibilities for recovery of valuable by-products from such wastes. While some industries have rectified this condition, others are still wasting valuable materials into the public sewers each year.

Most California cities have been forced to install sewage treatment plants to prevent pollution of streams and coastal waters, to permit the use of streams for irrigation and other purposes, and to protect the public health. Frequently, the addition of industrial wastes to these systems has led to deterioration of the sewer structures, interference with sewage treatment processes, and unjustifiable increase in the costs of maintenance and operation. Employees working in the sewers and drains have been killed by toxic gases from improperly discharged industrial wastes. Explosions in the sewers have injured children so seriously as to require hospitalization, and in addition have caused serious property damage. While a majority of such blasts are attributed to illuminating gas, there is reason to believe that improper disposal of wastes from dry cleaning plants, refineries, chemical plants, and similar industries has also been responsible.

Due to the rapid expansion of industry in California cities, the number of such problems has multiplied rapidly, and the application of principles of business management to municipal affairs has resulted in an increasing demand for the establishment of procedures as outlined in this report.

After mature consideration, the committee does not believe that a workable formula can be devised for the making of charges for inclusion and treatment of industrial wastes in all cities of the state. Such formulae have been worked out by several cities in the United States, and are included for reference only. These formulae were developed to suit individual conditions and cannot be expected to be universally acceptable or workable in other cities.

Instead, the committee recommends that each city and each industry consider its individual problem in the light of procedures outlined herein. Evaluation of all of the factors in each case is imperative, and each industry and municipality should engage, where necessary, competent sanitary engineers to insure a proper solution of the problem.

As this report is to be used by some who are not familiar with the terms used by sanitary engineers, a brief glossary is given at the end of this chapter.

As a result of cooperative works between industries and the various state agencies affected, millions of dollars are being spent by industries for construc-

tion of facilities to dispose of their industrial wastes properly.

In the treatment of a problem common to an industry, a group representative is often approached with the suggestion that the industry initiate research that will lead to the development of approved methods of waste treatment and disposal. Often this work, guided by suggestions and assistance of the state agencies concerned, has resulted in the recovery of by-products whose value soon pays for the cost of disposal facilities installed.

In an endeavor to arrive at an equitable means of solving this problem, common not only to California but to many other states of the Union, the California Sewage Works Association, an organization of engineers, state and municipal health authorities, sewage plant operators and others interested in public health and sewage works construction and operation, appointed an Industrial Wastes Committee at its meeting in June, 1944, at Fresno, California. This committee was instructed to study and report on methods and means whereby this whole matter may be taken up in a logical way and a satisfactory solution developed.

After various meetings of the committee, a sub-committee was appointed, consisting of Ray F. Goudey, E. B. Besselievre and Walter Humphreys, to study this matter objectively and to report to the main committee with recommendations for a coordinated course of procedure.

As indicated in the preface to this report, the sub-committee submitted its report and recommendations to the main committee on February 16, 1945, and after discussion this report was adopted and authority given to proceed on the basis of its recommendations. Acting on the recommendations of the sub-committee as approved by the main committee, committees were appointed representing each section of the report with personnel as listed elsewhere.

As each of these committees must cover in its section factors which interest the class of persons in that section, it has been decided, for the sake of elimination of duplication, to incorporate in this introductory chapter the basic parts of the report of the sub-committee, which include:

1. A survey of methods used at present in handling industrial wastes.
2. Factors to be evaluated in arriving at a charge, or basis of charge, for handling industrial wastes.
3. Check list of effects of industrial waste constituents on maintenance of sewers, operation of sewage treatment plants and final disposal.

These items follow immediately after this chapter. Also incorporated in this section, to act merely as a guide for what has been done at several cities and suggested for others, are the formulae and ordinances now used in certain cities to base charges for handling industrial wastes. *It is not intended that these formulae are correct or should be adopted for any California city without mature study and consideration.*

It is hoped that the persons concerned with the several groups will realize the tremendous and important problem which confronts us in endeavoring to arrive at a sensible and satisfactory solution and will accept this report in the way it is intended, namely, to be a basis for further co-operative consultation between representatives of the interested groups in an endeavor to work out a solution that will be reasonably satisfactory and not unduly burdensome to anyone concerned.

Glossary of Terms Used in the Report

B.O.D. (Biochemical Oxygen Demand)—The amount of oxygen, in parts per million, consumed in 5 days, at a temperature of 20° C., in the biological oxidation of organic matter

in a sewage, waste, or treatment plant effluent.

Chlorine demand—The amount of chlorine which must be added to combine chemically with the organic and waste material, so that there will be a specified residual of free chlorine.

g.c.d.—Gallons per capita per day.

p.c.d.—Pounds per capita per day.

pH—The index of a measure of the hydrogen ion concentration in a solution, the figure 7.0 denoting neutrality, a smaller figure meaning more acid and a higher figure meaning more alkaline. The numerical figure is the logarithm of the reciprocal of the hydrogen ion concentration.

p.p.m.—(parts per million)—The weight of the specified substance in one million parts by weight of the sewage and wastes examined. The expression "one part per million" is usually understood to mean one pound per million pounds of sewage.

Settleable solids—The quantity of sludge or solids or sediment (expressed in cubic centimeters per liter, parts per million, or per cent by volume) which will be deposited from a given quantity of sewage in a certain interval of time. Usually determined by use of the Imhoff cone. Two hours is the usual period of the test.

Population equivalent—The ratio of the pounds of 5-day B.O.D. contributed per day by an industrial waste to the pounds of 5-day B.O.D. contributed per day by domestic sewage per capita of population.

Extension of the use of the term "population equivalent" in making comparisons of putrescible waste disposal problems is recommended. There are other measurements of pollution, but any one chosen is dependent upon the relative importance of the factors of putrescibility, toxicity, and volume of the wastes to be handled in the particular situation. In general, it can be assumed that the "average person" in a city produces from 30 to 100 gallons of sewage per day; that the flow contains 0.5 pound dry weight of suspended and dissolved, removable, or oxygen-consuming solids; the suspended solids amount to 0.20 to 0.27 pound per person; and that 0.14 to 0.20 pound of oxygen is consumed over a 5-day period in the biochemical oxidation of the putrescible suspended and dissolved constituents per capita population producing a domestic sewage flow. From the standpoint of measuring or handling a liquid waste pollution problem, a satisfactory evaluation of the problem can be established by developing data and converting it to population equivalents using the aforementioned data.

Survey of Methods Used in Handling Industrial Wastes

A. Recovery of by products to reduce waste to a minimum:
   1. Changes in process.
   2. Interception of solids before reaching sewer.
   3. Recovery of valuable substances.

B. Conservation of water:
   1. Re-use of cooling water.
   2. Re-use of portions of wash and process waters.
   3. Prevention of waste of water.

C. Keeping refuse and bulk waste out of sewer:
   1. Substitution of mechanical conveyors for water carriage.
   2. Sweeping and other cleaning before flushing floors, etc.

D. Segregation and separation of wastes:
   1. Isolation of harmful or objectionable wastes.
   2. Separate disposal of most objectionable wastes.

E. Exclusion of outlawed wastes:
   1. Those affecting sewers.
   2. Those detrimental to sewage treatment plants.
   3. Those detrimental to final disposal sources.

F. Separate treatment and/or disposal by an industry.

G. Pre-treatment by each industry where advantageous to public sewerage systems or treatment plants:
   1. Screening.
   2. De-greasing.
   3. Settling.

TABLE 1.—Check List of Effect of Industrial Waste Constituents on Maintenance of Sewers, Operation of Treatment Plants and Final Disposal

Characteristics of Wastes			Sewer Maintenance				Treatment Plant Operation						Disposal				Consider outlawing on account of effect on:		
			Wastes usually are a problem when sewage is			Wastes may be advantageous	Clarification		Stabilization		Complete		Dilution		Land				
No.	General	Specific	Fresh	Stale	Septic		Usually a problem	May be advantageous	Usually a problem	May be advantageous	Usually a problem	May be advantageous	Usually a problem	May be advantageous	Usually a problem	May be advantageous	Sewers	Plant	Disposal
1	Flow	Uniform daily through year	X	X	X	X	X		X		X		X		X				
		Uniform hourly but seasonal	X	X	X	X	X		X		X		X		X				
		High hourly peaks	X	X	X	X	X		X		X		X		X				
		Discharge off sewage peak	X	X	X	X		X	X		X		X		X				
2	Chemical	Biological																	
		Bacteria			X														
		B.O.D.		X	X		X		X		X		X		X				
		Disinfecting				X			X		X			X		X		X	
		Fungi	X				X										X		
		Toxicity				X			X		X				X			X	X
		Mineral																	
		Acidity and alkalinity	X	X	X		X		X		X		X		X		X	X	X
		Acid sludge	X	X	X		X		X		X		X		X		X	X	X
		Brine				X							X		X				
		Coagulants				X		X						X	X				
		Dissolved oxygen				X		X		X		X		X			X		
		Metallic ions (Fe, Cu, Mn, Cr, Al, As)				X		X	X		X		X		X				X
		Nitrates				X		X		X		X		X			X		
		Softener sludge					X								X				
		Sulphate		X	X										X				
		Total dissolved solids			X										X				

NOTE: Characteristics noted may be found in a great variety of wastes and when such wastes are discharged into public sewers they may adversely affect or be advantageous to the maintenance of sewers, the operation of treatment plants, or to the method of final disposal, as indicated.

TABLE 1 (Cont.)—Check List of Effect of Industrial Waste Constituents on Maintenance of Sewers, Operation of Treatment Plants and Final Disposal

Characteristics of Wastes			Sewer Maintenance				Treatment Plant Operation						Disposal				Consider outlawing on account of effect on:		
			Wastes usually are a problem when sewage is				Clarification		Stabilization		Complete		Dilution		Land				
No.	General	Specific	Fresh	Stale	Septic	Wastes may be advantageous	Usually a problem	May be advantageous	Usually a problem	May be advantageous	Usually a problem	May be advantageous	Usually a problem	May be advantageous	Usually a problem	May be advantageous	Sewers	Plant	Disposal
	Chemical	Amines			X				X		X					X			
		Catalysts—inhibitors				X	X		X		X					X			
		Chlorine requirement		X	X														
		Gelatinous matter	X	X	X		X		X		X				X				
		Grease	X	X	X		X		X		X		X		X				
		Hydrocarbons	X	X	X		X		X		X				X		X	X	X
		Mash	X	X	X		X		X		X		X		X		X	X	
		Pulp	X	X	X			X	X			X	X		X		X		
		Sludge	X	X	X		X		X		X		X		X				
		Soaps, detergents	X	X	X		X		X		X				X		X		
		Starch		X	X		X		X		X		X		X		X	X	X
3	Physical	Corrosivity	X	X	X		X		X		X			X	X		X	X	
		Color									X		X						
		Crude Oil	X	X	X		X		X		X		X		X		X	X	X
		Sediment-silt	X	X	X		X		X		X		X			X			
		Temperature																	
		Normal←90° F.				X				X		X							
		Warm 90°–120° F.			X		X			X		X	X		X		X	X	
		Hot→120° F.		X	X		X						X		X		X	X	
		Volatile compounds	X	X	X				X		X		X		X		X	X	X

4. Storing peak flows to obtain uniform discharge.
5. Neutralization chemically or by combining with wastes from other plants.

H. Disposal into public sewage works:
1. Effect on sewer system (Table 1).
   (1) Excess sewer capacity still available but maintenance costs increased.
   (2) Use of sewers for industrial wastes infringes on domestic capacity as it increases.
   (3) Sewers already overloaded.
   (4) Use of sewers for industrial wastes at minimum flow periods of domestic sewage.
2. Effect on sewage treatment plants (Table 1).
   (1) Excess treatment plant capacity still available but operation costs would be increased.
   (2) Industry uses plant capacity reserved for increasing domestic load.
   (3) Treatment plant becomes overloaded because of industry and expansion is necessary.
   (4) Change in type of treatment is required because of inclusion of wastes.
3. Effect on final disposal (Table 1).
   (1) Modification of industrial wastes program to protect public against damages from final disposal due to industrial waste.
   (2) Change in final disposal because of industrial waste.

I. Disposal of wastes into waterways or storm drains:
1. Clear water.
2. Stable water.
3. Water meeting requirements of local ordinances and of State and Federal health laws.

Factors to be Evaluated in Arriving at a Charge, or Basis of a Charge, for Handling Industrial Wastes

A. Type of sewage treatment plant or disposal method used in a given municipality:
1. Discharge into stream—dilution only.
2. Preliminary treatment—screening, degritting, de-greasing.
3. Primary treatment—sedimentation and digestion.
4. Secondary treatment:
   (1) Chemical precipitation.
   (2) Biological treatment—trickling filters.
   (3) Biological treatment—activated sludge.

B. Designed volume of plant and the present percentage of volume used in treating the city sewage.

C. Capacity available in plant design for absorbing industrial wastes.

D. Type and character of wastes to be handled:
1. Volume.
2. Suspended or settleable solids.
3. B.O.D.
4. Toxic or destructive material or inhibitive elements present.

E. Policy of city as regards industry:
1. Whether city is obligated or committed to accept wastes.
2. Whether they feel it expedient or politic to handle the wastes of certain plants.
3. Whether the present plant will handle any excess capacity or whether new units or additional treatment will be required if wastes are included.
4. Amount of taxes contributed by industries to general city funds.

F. Basis of charges for handling industrial wastes:
1. Charging for entire load contributed by industrial plant on basis of
   (1) Volume.
   (2) Suspended or settleable solids.
   (3) B.O.D.
   (4) Chlorine demand.
2. Charging for excess loads contributed by industry in relation to composition of normal sewage of city:
   (1) Excess volume.
   (2) Excess suspended or settleable solids.
   (3) Excess B.O.D.
   (4) Excess chlorine demand.

G. Fixed charges:
1. Whether industrial plants should pay proportional charges of operation, such as interest on plant investment, amortization, obsolescence, etc.

H. Charges for maintenance:
1. Whether the industry shall be charged for its proportional share of maintenance charges on large sewerage systems, where these are recorded separately from sewage treatment plant costs.

I. Initial cost of plant:
1. Whether, in case an existing sewage treatment plant accepts industrial waste, the industry should be charged for its proportional part of the initial cost of the plant, on the basis of volume or other constituent contributed.
2. Whether industry should pay the entire cost of new units or for additional degrees of treatment required to treat its wastes, or pay only its proportional part as represented by its ratio of volume or load to the city's volume or load.

J. Rebate or reduction for taxes paid to city by industry:
1. Whether the total amount of taxes paid

by an industry should be deducted from the total of any charge arrived at for handling its wastes.

2. Whether only the proportional part of the taxes paid by an industry as represented by the proportion of the city taxes used for sewage treatment and maintenance shall be deducted from the total of any charge arrived at for industry.

K. Adjustment for beneficial wastes discharged by an industry. In some cases an industry may discharge a waste which would:

1. Tend to flush sluggish sewers and keep them from clogging or building up sludge banks.
2. Neutralize wastes contributed by other industries to the point where the flow would then not be harmful to structures or inhibitive to processes.
3. Precipitate sulfides from the sewage.

L. Adoption of a standard of maximum strength of sewage to be admitted to sewers and treatment plants:

1. Whether a maximum limit of suspended solids, settleable solids, B.O.D., etc., shall be set up by state or local agencies and an industry required to pay for all in excess of that or,
2. With a maximum demand set up for the above constituents, whether an industry can build its own treatment plant and reduce its wastes to the maximum allowable in the city standard and thus avoid payment of additional charges to the city for handling its wastes in the public sewers and treatment plant.

M. Consideration of charges to an industry that receives no other benefits from a city but pays large taxes. In some cases the taxes paid by an industry (*i.e.*, oil field wastes) might well be more than any charge that might be made for handling those wastes in a city plant. This would result in the city treating the wastes free if all taxes paid were rebated against the handling charge.

N. Consideration that industries which have mutually neutralizing wastes join together in joint districts to consolidate their several wastes and turn out an effluent within the maximum limit set, thus avoiding any charges.

O. Extent of requirement for pretreatment of any or all wastes before discharge into a public system.

P. Devising of a basic formula taking into account the various elements which can be used by any particular municipality in adjudging the charges to be made according to the polluting or disturbing elements contributed by any of its industries.

Q. Recommendations for an enabling act by state legislature to permit any particular city, county, or other local governmental agency, to set up regulations and devise formulae for charging for industrial waste treatment.

R. Recommendations that study of industrial wastes and basis of handling by city, county, or other local governmental agency, be made by engineers engaged in and familiar with this phase of engineering.

S. Recommendations that conferences be held between municipal officials, industrial plant management and engineers to arrive at a logical and satisfactory basis of charges.

Public Policy

A. Evaluate all capital, maintenance and operation costs, together with advantages gained by industrial wastes taken into public sewers.

1. Public system carries entire burden where city officials feel that such is to the best interests of the city because of—
   (1) Population employed by industry.
   (2) Taxes paid by industry.
   (3) Publicity given by industry to the city.
2. As a result of a meeting between city officials and industry an agreement may be reached as to the extent of participation by industry.
3. Industry pays that portion of capital, maintenance and operation costs offset by advantages received by the city as determined by a technical analysis of all the facts available.

B. Make an arbitrary charge based on volume and strength of wastes discharged into the public sewers where a large number of industries are concerned.

1. Buffalo, N. Y., method.
2. New Brunswick, N. J., method.
3. Anaheim, Calif., method.
4. Fullerton, Calif., method.

C. City guarantees free disposal to selected industries but charges others.

D. No charge whatever for any type of waste.

E. City approves use of waterways and storm sewers for disposal of wastes that are harmless from a health standpoint and not productive of nuisances. In the past there have been cities in California where the industrial load is many times greater than the domestic sewage load, resulting in the entire sewage disposal and treatment facilities of the city being completely abandoned. There have also been cases where industries have overtaxed sewers, requiring the laying of new and larger sewers. In some instances, cities have had to change their method of treatment and even their final method of disposal due to complica-

tions from industry. These and other points clearly raise the issue that there must be some sort of a working agreement between cities and industries.

Examples of Existing Formulae and Ordinances for Charges

Buffalo, New York[1]

Formula for basing charge for handling industrial wastes:

$$R = F \times Pc\ (C - Nc)\ plus\ F \times Ps\ (S - Ns)$$

in which

R = rate of special charge per 1,000 cu. ft. of volume of waste.
F = conversion factor to convert from parts per million to pounds per 1,000 cu. ft.
Pc = cost of chlorine per pound.
C = measured chlorine demand of waste in question.
Nc = normal chlorine demand of Buffalo sewage.
S = measured quantity of suspended solids in waste in question.
Ns = normal quantity of suspended solids in Buffalo sewage.
Ps = cost of chemicals and power as determined from plant operation.

New Brunswick, New Jersey[2]

In this case there is no formula but industries pay as follows:

$22.00 per million gallons of total flow.

$5.00 per ton of solids in the wastes.

$5.00 per 100 pounds of chlorine demand exerted by wastes.

In addition industries must minimize peak concentrations and produce wastes of acceptable quality by equalizing tanks or pretreatment.

In neither the Buffalo nor New Brunswick formulae is there any consideration given to the many other factors which obtain in different cases as outlined in this chapter. They arbitrarily charge for volume and other constituents with no regard for mitigating influences.

Anaheim, California, and Fullerton, California

As an illustration of what has been done in typical California cities, ordinances were passed in the cities of Anaheim and Fullerton permitting charges to be made against industries in these cities. These ordinances were No. 667 in Anaheim (February 29, 1944); and No. 490 in Fullerton (July 6, 1943).

Harold Farnsworth Gray, Consulting Engineer, Berkeley, California, in an article entitled "The Responsibility of the Municipality in the Industrial Waste Problem," published in Sewage Works Journal, November, 1944, discussed a method of charging industries for their wastes.

Section 1. Factors Affecting Chambers of Commerce

In most California cities the development and location of new industries within a city is a competitive effort carried on by the local chamber of commerce through its industrial department. This activity is carried on in order to:

a. Furnish industrial employment for the community.

b. Increase the community's taxable assets.

c. Increase business for those who sell to industries.

When an industry considers locating in a community, careful consideration should be given not only to the adequacy of power and water facilities but also to waste disposal arrangements. "The city has sewers" has often seemed to be a sufficient statement to assure that all liquid wastes would be cared for at public expense.

If subsequent experience shows that the wastes from a plant which has located under these conditions are over-

[1] Formula Set Industrial Waste Treatment Fee at Buffalo, *Sewage Works Engineering*, October, 1944; pp. 543–544.

[2] This Journal, **16**, 4, 678 (July, 1944).

loading the sewers or disrupting operation of the treatment plant, the city is likely to lay the entire blame on the industry and require the industry to build a treatment plant of its own or to expend unanticipated sums of money for sewerage charges.

In order to avoid unsatisfactory situations of this sort, the following points are suggested for consideration:

1. Although the city engineer or superintendent of sewers may not be an expert on industrial waste problems, he should know where to secure the necessary information to evaluate the probable effect of certain types of wastes when added to the sewage. He should be familiar with the book, *Industrial Waste Treatment Practice*, by Eldridge, with this report and with other pertinent publications. For the more difficult or unusual types of waste he should use the services of consultants who are experts in this field.

2. The chamber of commerce should give just as much consideration to waste disposal as to other utilities. The chamber should discuss with the city engineer or superintendent of sewers the location of any industries which could conceivably have waste problems. In some cases a knowledge of sewerage facilities may be important in choosing a proper location within a general metropolitan area.

3. The city should not lose sight of the fact that its purpose is to serve the whole community, including industries. Industries do not seek unfair advantages for themselves, but they do not like to be barred from the use of a community facility. Some cities have required industries to erect expensive small treatment plants of their own, whereas the wastes might have been cared for along with the city sewage with an increase of operating cost only a fraction as great as the cost of the separate plant operated by industry. Sometimes this condition arises because the city has not established an equitable basis for assessing costs, and sometimes the city simply does not want to be bothered. A comprehensive co-operative waste disposal scheme is certain to be cheaper than a lot of decentralized systems. Lowest total cost is the sensible criterion; a reasonable basis for distributing the costs can always be found.

4. In small cities with industries which place excessive burdens on sewerage facilities, it is essential that the industries be charged for waste disposal if this is handled by the city. Equitable basis for charges is discussed elsewhere in this report. If all users of the sewers pay service charges, the industry pays along with the rest. If other users do not pay, then the industry is entitled to credit on its waste disposal account for taxes paid.

5. In large cities which assess sewerage service charges to all users, the industry also pays along with the others. Industries should not seek rates inequitably favoring themselves, else they will ultimately become the targets of restrictive ordinances. In large cities where service charges are not applied, it is frequently possible for the city to care for the industrial wastes along with the rest of the sewage without any special arrangements. This is the most common practice at present. But even where such policies prevail, there are often small industries which cause substantial direct increases in sewage works operation costs. Examples are wastes which increase chlorine demand where the sewage is being chlorinated, or which contain sulfides where sulfide control is practiced. Generally, special agreements can be worked out with such industries whereby they undertake to pay part or all of the increased operating costs.

6. It is highly desirable that industrial waste policies be reasonably uniform throughout the state, or better, in all the Pacific Coast states. Otherwise, industries will be attracted to those cities where the public in effect subsidizes the industries by paying for waste

disposal, and those cities which follow more rational plans will be the victims of unfair competition.

Section 2. Factors Affecting Industrial Management

Significance to Industries

This section of the report emphasizes phases of industrial waste disposal problems of interest to the owners and managers of industrial plants.

The intent of the introductory chapter is to point out all the things that must be considered in typical cases, and it is hoped that the industrialists will study them seriously, will endeavor to ascertain wherein they may be causing trouble, and will co-operate with the various interested parties to solve the problem amicably and practically with the least expense and annoyance to the citizenry and with a minimum burden to the industry.

It is hoped that the issuance and wide circulation of this report to the managers of industry, to municipal, state and federal officials, engineers and others will engender a desire and a willingness on the part of all to co-operate in handling these difficult problems for the common good.

Who Pays for Industrial Waste Disposal?

In general, industries wish to avoid the expense of treating their wastes and so try to locate where they can discharge them with a minimum of treatment to watercourses or where they can use local sewerage facilities and treatment works.

Because of the volume and character of some industrial wastes, their discharge frequently creates a situation which leads to fouling of streams, odor and other nuisances, deposits in harbors, damage to city sewerage systems and sewage treatment plants, and excessive operating costs. As a result, movements are on foot in many localities to set up some basis for making equitable charges which industry will be called upon to pay in those cases where their wastes are known to cause unusual increases in costs of operating sewage works, damage to the system structures, or nuisance. Under these situations it is always difficult to allocate costs justly. In general, the questions raised are about as follows:

(a) Should the city bear the entire cost of collecting, transporting, and treating industrially produced increases in sewerage system loading?

(b) Should industries bear the entire cost of liquid industrial waste treatment and disposal?

(c) Should there be some form of prorating additional cost to industry, based on these accruals, for handling liquid industrial waste flow?

Difficulties in Establishing Bases for "Back-Charging"

Study of the factors summarized in the introductory chapter shows that it is difficult to establish an empirical formula to use as a basis for calculating charges to be assessed against industries discharging many different kinds an unusual quantities of liquid industrial waste. In order that any such formula be suggested for use in enforcement of law and for incorporation in ordinances of all types of cities, it would be necessary to show that it allowed for consideration of the diversity of the situations facing the managements of industry. Obviously, it is impossible to suggest an empirical formula pretending to be of such general usefulness. On the other hand, management of any industry recognizes some responsibility to the public that makes up the community in which it is established, and the management is usually ready to accept a fair share of responsibility for governmental costs of maintaining the services for the community from which they draw their personnel. In general, an agreement can be reached between governmental officials

and management of industry with regard to the evaluation of the factors leading to increases in municipal operating costs for handling industrial wastes, and from this basis a method can be established for allocation of percentages of the cost to industry and to the city.

Typical Industrial Waste Pollution Situations

Industrial wastes are included under the term sewage in Chapter 6 of the Health and Safety Code, which sets up a permit system under the State Department of Public Health for regulating the disposal of all such wastes, including changes and alterations in the systems.

Sewage is very broadly defined as (a) sewage, garbage, feculent matter, offal, refuse, and filth, and (b) any animal, mineral, or vegetable matter or substance offensive, injurious, or dangerous to health. The Act makes it a violation of law to construct or use sewers, conduits, or works for the treatment or discharge of any of the above substances or to alter the system or place of disposal without a permit, whenever the discharge is to be into (a) any waters including the subterranean water used or intended for use for water supplies for humans or animals, or (b) the overflow is onto lands, or (c) into the salt waters of the state. Thus, practically every place of disposal comes within the Act.

The law applies not only to cities, counties, and all districts, but to any person, firm, association, organization, partnership, business trust, corporation, or company. In the case of industries using public sewer systems, it is held by the State Department of Public Health that the governing board of the sewer system is the party responsible for permit under the law, and dealings with industries using the system are private matters between the company and the industry. However, conditions of permit granted to cities have sometimes limited industrial use of the sewers where disruption of the sewage disposal system would otherwise result. It may be necessary to make more frequent recourse to this procedure, as industrial wastes greatly alter the sewage disposal of communities. Industries having their own disposal systems, of course, become the principals under the law.

The duty to apply for permit is upon the person responsible, and the department is taking account with increasing concern of failures of industry to conform with the law. There are a number of situations that illustrate the reason for the concern of the moment with respect to the effect of discharge of industrial waste through sewerage systems or directly into natural watercourses.

By reason of the extensive fruit and vegetable dehydration and canning operations in the Modesto area there is a length of Tuolumne River so polluted as to be completely devoid of dissolved oxygen. The pollution of the Tuolumne River at this time does not represent a health hazard but is extremely important from a standpoint of sport and commercial fishing. Fish do not cross such an oxygen deficiency barrier as exists at Modesto and thus, for example, salmon have tremendous difficulty, if they are able at all to reach their spawning grounds.

The high percentage of manufacturing from which putrescible industrial wastes are produced can be illustrated by the fact that 25 per cent of the national tomato juice output is processed in California, and 60 per cent of the fruit and vegetable canning operations performed in this state are undertaken in plants discharging wastes along the easterly and southerly shores of San Francisco Bay.

There have been complaints of pollution of underground waters by industrial wastes. The proof of such contamination of well water is difficult, because investigational work on this

phase of the problem is limited. Some clear cut evidence of realities in connection with industrial wastes pollution of underground waters has developed in cases where wine distillery and citrus fruit processing plant wastes have been discharged into disposal or injection wells. In the first situation, the discoloration and iron content of the water indicated the origin of the pollution, and in the second case, the analyses of the water showed unusual concentrations of boron.

Treatment of Industrial Wastes

Under many situations it is more economical for industry to undertake a certain degree of pretreatment of industrial wastes in order to lower the prorated charges that can be rebilled to the industries by the municipality.

At the outset it should be recognized that the dilution of industrial waste with large quantities of waste waters is not a form of treatment. Invariably dilution of industrial waste increases the ultimate handling cost whether directly or through taxation. The pollutional loading caused by industrial waste is frequently ten to twenty times that caused by the equivalent gallonage of domestic sewage.

Treatment of industrial wastes may include applications of one or more sewage treatment processes, namely: screening, skimming, chemical treatment, flocculation, coagulation, vacuum flotation, disinfection, biological oxidation and nitrification, by-product recovery, water conservation, land irrigation, dehydration, sludge digestion, and neutralization of toxic components. These treatments are usually accomplished in adaptations of plants similar to domestic sewage treatment plants.

Frequently, recovery in the plant of part of the material that would otherwise become waste may repay some of the cost of treatment, as well as greatly reduce the requirements for treatment. Two recent examples of profit from recovery can be found by reviewing the history of solutions of waste disposal problems in connection with the operation of synthetic rubber plants and of wine distilleries. In the first case, treatment of liquid industrial wastes resulted in the recovery of valuable rubber fines, and in the second case proper treatment of wine distillery slop resulted in the recovery of large volumes of calcium tartrate.

Appraisal of Extent of Particular Problems

In appraisals of the extent of the industrial waste pollution loadings the following expressions and relationships are employed:

(a) Value of products manufactured in any area.

(b) Number of persons employed on waste-producing work.

(c) Quantities of particular products processed in an area, whether expressed in "tons per year," "gallons per year or day," or "number of cases packed."

(d) Gallons of waste produced per operating day and the rate of discharge calculated per 24 hours.

(e) Content of suspended solids, usually as p.p.m., but sometimes in pounds per average operating day.

(f) Biochemical oxygen demand in p.p.m. or occasionally as weight of oxygen that must be taken from the land or streams each day for stabilization of the pollution loading.

(g) Population equivalent as determined from the strength and volume of wastes.

Governmental Agencies Concerned

Because the effects from discharge of unusual quantities of liquid industrial wastes often extend beyond the sewerage system and the sewage treatment plant, it is usual for both the general

public and a wide variety of enforcement agencies to be concerned with the problem.

The various representatives of governmental agencies whose interest may require their entry into the discussions of liquid industrial waste disposal practice are those charged with responsibility for adjudication of use of natural resources, protection of the public health, protection of fish and game, abatement of visual or odorous nuisances, maintenance of port and military securities, and protection of private rights.

1. Municipalities:
   a. Department of Health.
   b. Department of Public Works.
   c. City Engineer or Superintendent of Streets.
   d. Department of Water Works and Sewerage.
   e. Harbor Department.
2. Counties:
   a. Health Department.
   b. County Surveyor and or/ County Engineer.
   c. Sanitation Districts and Sanitary Districts.
   d. Flood Control Districts.
   e. Sewer Maintenance Districts.
   f. Public Utility Districts.
   g. County Planning Commissions.
   h. Drainage Districts.
   i. Mosquito Abatement Districts.
3. State of California:
   a. Department of Public Health—Division of Environmental Sanitation, Bureau of Sanitary Engineering.
   b. Department of Public Health—Division of Preventive Medical Services, Bureau of Adult Health.
   c. Department of Natural Resources—Division of Fish and Game.
   d. Department of Public Works—Division of Water Resources.
   e. State Department of Agriculture—Division of Animal Industry.
   f. Division of Lands.
   g. State Park Department.
   h. Housing and Immigration.
4. United States Government—Public Health Service.
5. United States Government—War Department.
   a. Harbor Security Committee—Army, Navy, and Coast Guard.
   b. U. S. Engineer Office—River and Harbor, Flood Control Branch.
6. United States Government—Department of Agriculture, Department of Food and Drugs, Bureau of Animal Industry.

In addition, many private interests and industrial groups may be affected as a result of discharge of liquid industrial wastes by other interests. These groups usually are large landholders of the area, private water companies, and other manufacturers or industrialists.

Ultimately, the interests most active in abatement of water pollution are those concerned with maintaining native conditions insofar as this is possible. Principal among the active groups are health authorities and the sport and commercial fishermen.

Protection of Individual Rights *vs* Economics of Waste Disposal

The attitude of the pollution control enforcement groups can be summarized as accessions to the general public demand for maintenance of the countryside, its waterways, and the atmosphere in the natural and uncontaminated condition associated with native situations in rural areas.

In general, the economy of pollution control has little bearing on rulings or formulations of policy. Where the interests or rights of private property are involved usually the number of people affected or the cost of correction as against the value of the rights has little bearing on the attitude of enforcement groups concerned with the abatement of nuisance and control of pollution.

Enforcement Attitudes and Practices

Other sections of this report point out the attitude and jurisdiction of the several pollution control enforcement agencies. In this connection industrial management should keep in mind that the purposes and action of these agencies do not always conform, from the standpoint of practice, with the purposes and action as represented in

the laws they are authorized to enforce.

Federal agencies enforce the Rivers and Harbors Act and the Refuse Act principally in connection with oil and garbage pollution in coastal and harbor waters. In general, these agencies have no interest in the manner of correction or the cost of correction of violations, and they utilize the courts for punitive and corrective procedure. The responsibility and attitude of these agencies should not be taken lightly. The U. S. Engineers and U. S. Coast Guard are inflexible in their enforcement attitude and practices because they are charged with responsibilities for prevention of sludging of navigable channels, port fires, damage to vessel bottoms and, in time of war, with innumerable related security hazards.

Within the state the Division of Fish and Game, Pollution Control Detail, has been active for some years past. Their work is fundamentally restricted to violations that damage or affect the conservation of fish and game. Their funds, however, are derived principally through sportsmen, which necessitates prime consideration being given to the overall desires of this group, whose interest is maintenance of pristine natural conditions so that recreational pleasures of camping, fishing, etc., are not encroached upon, irrespective of whether actual damage to fish life can be shown. While the Division of Fish and Game is primarily an enforcement agency and acts as such on the complaint of others, it has initiated and prosecuted many violations in court. The Division of Fish and Game has had a successfully operating cooperative agreement with other agencies. Similarly, while fundamentally a law-enforcing group, this division has dealt on a co-operative basis with many industries and worked with them toward an equitable and satisfactory solution of certain waste disposal problems without recourse to the courts. The Division of Fish and Game has acted on many cases where their inspections and investigations disclose that a condition of pollution exists regardless of whether complaints are first filed.

The State Department of Public Health, through the Bureau of Sanitary Engineering, is authorized to require permits for industrial waste discharge elsewhere than to municipal sewerage systems. In practice they do not initiate demands on industry to apply for permits, but rather act cooperatively to call attention to possibilities of nuisance. When a permit is requested, however, advice is given with respect to specific requirements. Many industrial waste pollution situations have gone unnoticed when permits have not been requested until complainants call on the bureau or the court's action. The Bureau of Sanitary Engineering deals primarily with municipal sewage disposal through review of plans for sewage treatment improvements. The bureau also assists municipalities in improving plant operating practices. It has utilized the quarantine procedure frequently but in very few instances has it resorted to the courts for remedial action excepting where actual complaints have been filed. However, when industrialists are brought into court on complaints of causing nuisance and it is determined that wastes have been discharged onto land or into waters without permit, these concerns are in a weak legal position.

Correlation of Viewpoints

In many cases the divergence of viewpoint between management of industry and enforcement agencies is such that agreements between them can be made only through the services of technically qualified professional men selected by both groups.

The situation often develops where pollution control authorities make common understanding difficult by assuming that industrialists are taking unfair advantage of local conditions and are taking part in the process of converting

California streams to western equivalents of the Delaware River.

On the other hand, the situation often develops where industrialists and their operating engineers start with the assumption that California is so big that ample isolation for nuisance-producing industries is available and that this isolation is properly an asset that can be used to the benefit of industry. In addition, industrial management fails to inform itself of the responsibility of the pollution control agencies and assumes that it is being "picked on" for some political reason.

In cases where a municipality feels that damage is being done to its sewerage system and that a "back-charge" should be made to the industry causing the damage and where industry feels that as taxpayers they have a right to complete sewage collection and disposal service, both should agree to call upon qualified professional men for conciliation agreement services, for impartial studies of the problem, for surveys of the factors involved, and to give professional recommendations as to the nature of an equitable solution to their differences.

Most of the situations that have developed into court cases can be traced to failure on the part of both sides to make sufficient effort toward understanding the problems of the other. It is clear that industry has some rights to use the public sewage works of municipalities in which their operations are headquartered. On the other hand, if the cost of operating the industry as a private venture is being assessed in part against the taxpayer, the municipal authorities have a right to request agreement on a basis for back-billing such inadvertent transfer of operating cost of private industry to public taxpayers.

It is the intent of the committee preparing this report to point out the multitudinous factors involved, to indicate duties and responsibilities in each agency, and to initiate discussion of the problems so that the basis for meeting of several minds may be established.

Section 3. Factors Affecting Sewage Works Operation

Industrial wastes and their effects upon the operation of sewage treatment plants present problems as varied as there are methods of treatment and variety of wastes.

Where a high degree of treatment of sewage is necessary it follows quite logically that closer attention to, and control of, industrial wastes is highly desirable. It is not intended to infer, however, that where a lesser degree of treatment is used that these wastes are not harmful, as this type of plant can also be rendered wholly ineffective as far as accomplishing the purpose for which it was designed. Sewage treatment plant operators generally are willing to take anything the plant can handle without seriously upsetting the proper functioning of the process. It is believed that nearly all will agree that wastes known to be harmful to structures, or that interfere with the successful operation of a process, should either be pretreated, excluded, or the rate of discharge into the sanitary sewer regulated. There are instances of record which demonstrate that wastes known to be harmful in large uncontrolled amounts are beneficial to plant operation with controlled discharge. Fats, oils, greases and petroleum products, often emptied into the sewer legally or otherwise, usually have a deleterious effect upon treatment processes and their exclusion or removal from the sewage ahead of the treatment process is desirable and in some cases essential.

Since many industrial wastes are high in organic content as well as high in temperature, they can cause a condition in the sewerage system resembling an incubator with a large store of food for the sulfide splitting organisms. In this case it is necessary to stabilize

the waste in order to reduce the odor nuisance along the sewer line and at the plant, and to protect the sewer and plant structures from disintegration by these gases.

It is unquestionably true that many industrial plant owners are unfamiliar with problems arising from the discharge of wastes into the sanitary sewer and many would no doubt willingly co-operate to alleviate a detrimental condition. It is only in recent years that this phase of the matter has been given the attention it deserves. In many cases municipal officials are also not fully aware of the effects of industrial wastes on sewers and treatment processes, and many plants have been built on the assumption that only domestic sewage is to be treated. One garage or service station can represent a potential waste problem.

It seems reasonable to assume that a definite policy regarding the admission of industrial wastes into sanitary sewers should be established by the agency operating a sewerage system. Rules and regulations to carry out the policy can then be formulated. If sewage disposal is by joint agreement or contract between cities, centralized authority for controlling industrial waste discharge is desirable.

During the past few years we have seen in this state the rapid increase of small manufacturing plants, which often produce some form of industrial waste. If, as is believed likely, many of these establishments are to be permanent, some cities will have to provide facilities at existing plants to take care of the increased loading, due either to an increase in flow or a change in character of the sewage which would make the present plant inadequate.

It is not unusual to find a plant which has been operating normally, almost entirely ineffective within a few hours due to some waste being emptied into the sewer. The operator must make the best of it until the source and nature of the waste can be determined and corrective measures taken. This all takes time and, in the case of infrequent discharge of wastes, may run into months before the trouble is located and corrected, resulting in periodic upsets of the plant. Often those charged with the control of industrial wastes are not sufficiently familiar with the effect of those wastes on plant operation, nor do they have the legal means available to enforce correction.

The above represent only a fraction of the problems the plant operator must contend with from industrial wastes. If an operator suggests exclusion of industrial wastes from sanitary sewers it probably indicates that too little has been done to control the wastes so that they can be handled reasonably by the treatment plant and process.

There are many industrial wastes encountered in the operation of sewer systems and sewage treatment plants, some of which are harmless, some detrimental, and a few actually beneficial. Obviously, each case must be approached individually and solved on its own merits, but a clear, broad policy, backed by extensive study and research and issued by high authority, would be extremely helpful as a guide and basis for negotiations in regard to industrial waste disposal problems.

Existing statutes should be clarified and additional legislation passed, if necessary, in order to put teeth in enforcement proceedings against industries which refuse to cooperate.

The whole matter, in the final analysis, is one of cost of disposing of troublesome industrial wastes and of who shall pay the price. In many cases, industries will agree to pretreatment of their wastes; in others, the industry may prefer to pay the municipality for the cost of disposal. In still other cases, the municipality may agree to take a waste without cost to the industry. But in any event, a sewage treatment plant designed to treat a certain volume and strength of sewage in the interests of public health and

comfort should never be called upon to receive and treat an industrial load which will cause the plant to fail in the performance of the prime function for which it was intended.

Section 4. Factors Affecting Local Government Agencies

No fixed policy can be set up for all cities to follow in connection with the treatment and disposal of industrial wastes. There are entirely too many factors involved in different cities to make one rule applicable to all. Some of these factors will be pointed out in this section and discussed so that any interested city can appraise the problem which exists in that city.

Types of treatment vary over a wide range from simple disposal by dilution in the ocean to complete treatment whereby a fully purified effluent is obtained. Few plants will actually produce a perfect effluent, so the California State Board of Health has wisely established regulations controlling the use of all sewage effluents.

Means of disposal by most western cities will fall into one of the following groups:

1. Discharge into large bodies of water (streams, ocean, lakes) — dilution only.
2. Preliminary treatment, screening and degritting only. Remainder of sewage disposed of by dilution.
3. Primary treatment by sedimentation and digestion. Effluent disposed of by dilution.
4. Primary treatment by sedimentation and digestion. Secondary treatment by one of the following methods:
   (a) Chemical precipitation.
   (b) Biological treatment — trickling filters.
   (c) Biological treatment—activated sludge.

Effluent from these processes can be disposed of in many ways: by dilution, by spreading on land, by use in irrigating crops, or by a combination of these means.

It is obvious that the cost of treatment increases for the different types mentioned, in the order named. Some revenue can be obtained from the higher types of treatment through the sale of digested sludge for fertilizer, and in the case of Group 4, through the use of effluent for irrigation of crops. In general, however, revenue is incidental.

The method of disposal and the type of plant operated by a city is dependent upon several factors, chief of which are the following:

1. Location. Proximity or lack of proximity to streams, large bodies of water, or other places of ultimate disposal.
2. Existing facilities.
3. Financial limitations.

Ability to take on an industrial waste load is dependent upon several factors, some of which are:

1. Capacity of existing facilities.
2. Physical conditions and financial ability to enlarge facilities to care for quantities beyond capacity of existing plant.
3. Effect of specific industrial wastes. A waste which would be impossible to handle through a small plant might have little effect on a large plant.

The question of how far a city should go in disposing of industrial waste must be answered by each individual city, as a matter of local policy. The use of municipal facilities by industry must, therefore, be appraised in view of the value of the industry to the overall welfare of the community. Where an industry is the main support of the community, a city may feel morally obligated to assist that industry in caring for its waste. Where an industry contributes to the community welfare by reason of a large payroll, high taxable value, generous contributions to

civic affairs, valuable advertising or the attraction of other industries, a city may find it is expedient to assist in the handling of industrial waste.

In order to have any control over industrial waste discharged into a public sewer, an application for permit should be required from all industrial users or prospective users of the sewage disposal facilities, showing the chemical composition and other characteristics of its wastes. Such application should include the following items:

1. Volume. Normal uniform flow, peak flow, and facilities for retention of flow to level off peak loads.
2. Suspended or settleable solids.
3. B.O.D.
4. Chlorine demand.
5. Temperature.
6. pH.
7. Oil.
8. Grease.
9. Sulfides.
10. Maximum size of solid particles.
11. Chemical contents (constituents which might affect the sewer lines or treatment plant through action on concrete or steel, inhibition of bacterial processes, etc.).
12. Odors or other nuisances.
13. New facilities required.

A definite contract should be entered into between the governmental agency and the industry based upon one of the following policies:

1. Handle all wastes without charge. This may amount to an actual subsidy of the industry by the community.
2. Charge the industry according to the unit cost of handling the waste, based on cost per million gallons, pounds of B.O.D. or dry weight of solids.
3. Charge the industry for the extra cost of treating the industrial waste, *i.e.*, the extra cost above that of treating the sewage of domestic quality.
4. Charge the industry for treating its industrial waste but take into account all taxes paid exclusive of industry. This can be computed according to the following formula suggested by the committee:

T = all taxes paid to city exclusive of industry.

t = taxes paid by industry.

S = cost of operating sewerage works before industry contributes, paid by T.

s = industry's share of sewage works operation cost, without industrial wastes added, paid by t.

$$s = Ts/T.$$

M = cost of operating sewage works with industrial waste added.

K = extra cost assessed to industry.

Then $K = M - (S + s)$

$$= M - S - (t + Ts/T).$$

Section 5. Factors Affecting State Agencies

While many agencies and subdivisions of the state government are affected by problems of industrial waste disposal, the following are directly concerned and have specific powers under existing state laws. New industries locating in a state should always be certain that their plans for disposal of liquid wastes are approved by the proper agencies. Also, reports of violations by existing industries should be made to them for corrective action.

Detailed statements of procedures and policies of the various agencies are given elsewhere in this report.

1. *The State Department of Public Health, Bureau of Sanitary Engineering.* This bureau operates under provisions of the State Health and Safety Code. The policy of the bureau is to secure co-operation of industries wherever possible and to resort to legal action only in cases of flagrant

and willful violation affecting the public health and safety.

2. *The Department of Natural Resources, Division of Fish and Game.* This division operates under the Fish and Game Code, the Health and Safety Code and federal laws. Its powers are chiefly regulatory and educational and are concerned with the protection of fish and animal life, pollution of streams, lakes, beaches, and other watercourses and abatement of nuisances. It has no power to act when damage is confined to agricultural, industrial, or recreational areas, or when there has been no effect upon fish or animal life, or upon navigable waters. The policy of the division has been to seek co-operation of industry wherever possible and to resort to legal action only in cases of flagrant and willful violation of the law.
3. *Department of Public Works, Division of Water Resources.* This division operates under the new Water Code and is chiefly concerned with prevention of pollution of underground water storage reservoirs and other valuable water supplies. Policies and procedure are in the formative stage.
4. *Other departments and commissions.* In certain specific instances other departments and commissions should be consulted relative to waste disposal problems. For example, the State Debris Commission is concerned with the construction of dams or similar structures for the impounding of debris or solids contained in mine wastes, and the Division of Mineral Resources exercises certain jurisdiction over wastes from mines, oil wells, and similar developments.
5. *County departments.* Few persons realize that various county departments are in many cases operating as branches or subdivisions of the state government. In such cases they are empowered to issue permits and enforce regulations imposed by state law. The County Health Department operating under the Health and Safety Code as well as local ordinances and regulations, is an excellent example. Certain powers are also delegated by the state to the County Board of Supervisors and to various other county departments. These agencies should always be consulted first in regard to a problem of local or regional character.
6. *Special districts.* Certain special districts have specific powers under various state laws and should be consulted whenever problems arise within the limits of their jurisdiction. Sanitation districts, sanitary districts, flood control districts, and public utility districts come within this category. These districts may issue permits, enter into contracts, regulate disposal and perform related functions as autonomous agencies of the state government.

Typical Problems

Files of the various agencies contain numerous records and reports of damage caused by industrial wastes in all parts of the state. In many cases the public health and safety has been impaired or endangered. Domestic water supplies have been seriously polluted or even destroyed by industrial wastes containing phenol, mineral acids and corrosive substances of every description. Fish and animal life has been destroyed. In one instance copper-bearing wastes from a single mine shaft destroyed fish life for more than sixty miles along an important stream. Streams, lakes, beaches and other watercourses have been polluted. Recreation areas and agricultural lands have suffered unnecessarily.

New Industrial Development

Handling of the problems developed by industrial expansion during the past five years has seriously taxed the resources of every state agency affected, not only because of shortage of manpower and funds, but also because of inadequate legislation and lack of established procedures for coordination between various departments and divisions.

In 1939 only four other states in the Union outweighed California in the value of manufactured products whose wastes constitute a serious disposal problem. Industrial development has accelerated greatly since 1939 and there is reason to believe that the movement has barely started. New basic industries of every description are choosing locations for postwar development in almost every section of the state. To handle this expected development efficiently, certain basic changes are necessary.

For example, when an industry has obtained a permit from one agency, and is complying with the laws, rules or regulations of that agency, it is essential that there be no question of violation of the laws, rules or regulations of another agency.

Recommended Changes

Procedures must be developed so that applications for industrial waste disposal are efficiently processed and approved by each agency affected. Budgets must be adequate to provide needed personnel, so that no application will be unnecessarily delayed. Legal provision must be made for joint action of the various agencies when necessary, in the issuance of permits, the coordination of educational programs, or the prosecution of violations. Funds must be available for cooperation with industry in the conduct of research essential to the solution of new and complicated problems.

Finally, the inspection of facilities installed and the enforcement of rules and regulations must be standardized and thoroughly coordinated if the program is to succeed. All of these things can be accomplished through cooperative effort, although a single agency working alone can do but little.

Section 6. Factors Affecting the Sanitary Engineers and Consultants

The fact that most civil engineering undertakings are "tailor-made" adds to the perplexing problem of combining all known factors to provide the best and at the same time the most economical means of disposal of sanitary sewage and industrial wastes for a community, be it incorporated or otherwise. Without doubt, the picture becomes clouded more often by the introduction of industrial waste than from any other cause. The content in this section is intended to assist the engineer in taking full cognizance of all of the facts as well as full advantage of all natural and other phenomena bearing upon the final solution of sewerage problems.

This setting down of procedure in orderly sequence and directing attention to as many of the potentialities of the problems as come to mind is dictated by many years of experience and observations in which it has been noted that wrong or inconsequential factors have all too many times guided solutions. The engineer must select such limits as he knows most readily apply to each situation in question.

With particular respect to the manner of payment for treatment of industrial wastes in sewage works, it first becomes necessary to determine when and how the wastes from an industry commence to burden the facilities. Obviously, if from the area of a manufacturing establishment there is no more waste in quantity or character than from an equivalent area of residential development, the two areas may be considered equivalent and it is no

more just to conclude that one is overloading the treatment plant or the sewers than the other; *i.e.*, they should be treated alike. But when the flow of industrial wastes from the manufacturing or industrial area of equivalent size exceeds the flow from the domestic area and greatly exceeds it in strength, toxicity, or otherwise, then the industrial load may be said, under some circumstances, to be overtaxing the sewerage facilities. Such comparison offers a means of determining when an industry may or should be asked to bear a part of the costs over and above that which would ordinarily be assessed against an equivalent residential area or a residential area of equivalent valuation.

For this purpose the following limits are suggested:

With respect to zones, it may be assumed that the population therein per acre at absorption may be:

(a) Residential—15 to 25.
(b) Income residential—25 to 125.
(c) Business—125 to 500 (for about 8 hours per day).

Per capita population contribution may be expressed, using the following approximate limits:

(a) Volume—30 to 100 g.c.d.
(b) Suspended solids—0.2 to 0.27 p.c.d.
(c) B.O.D. (5-day)—0.14 to 0.2 p.c.d.

From the foregoing the engineer may select those values which are appropriate to the area under consideration, and having done so he may assume that an industry should be allowed to contribute acre for acre the same quantity of wastes of equal or lower strength characteristics as the highest selected value in business or residential income zones, and that any excess in volume or strength may form the basis of charges against the industry for sewage works service.

Any one or all of the following four sewage characteristics may, under varying conditions, be made the basis of excess charges for industrial waste disposal:

1. Volume.
2. Suspended or settleable solids.
3. B.O.D.
4. Grease and oil content.

Volume may be considered the criterion:

(a) When B.O.D. and suspended solids are not critical factors.
(b) Where capacity limitation in the sewers is the only factor.
(c) Where the plant characteristics are materially disturbed by the increase in flow volume.

Obviously the implications involved in a material increase in the volume of sewage flowing into and from a plant are much graver where the tendency of the increased flow, regardless of its strength characteristics, is to so disturb the plant functions as to affect materially the quality of the plant effluent.

Settleable or suspended solids content of an industrial waste may be made the basis of an extra charge for its disposal:

(a) When deposits in sewers cause excessive maintenance costs.
(b) When additional facilities are required to handle solids at the treatment plant.
(c) When its load influences the efficiency of the method or means of final disposal to the extent that final disposal undergoes degradation.

The increased 5-day B.O.D. caused by the industrial waste may be made the basis for additional charges for its disposal:

(a) When the increased strength materially affects the generation of hydrogen sulfide in the sewers, requiring chlorination or

other treatment for control, and the increased cost can be directly evaluated.

(b) When the functions of an oxidizing sewage treatment plant tend to degrade because of overloading.

(c) When the effluent from such a plant is degraded, requiring chlorination or further treatment.

(d) When the place or type of final disposal is materially degraded because of the increased strength of the treatment plant effluent.

Grease and oil may be used as a basis for charges for the disposal of industrial wastes:

(a) When the cost of removal of the oil at the source is to be charged against the sewage works authority.

(b) When the grease content of the sewage increases the cost of line maintenance.

(c) When the cost of removal of grease at the treatment plant is materially increased by the addition of the industry's waste.

Preceding this discussion of the four general characteristics of sewage, our comments are intended to indicate that unless the entire system is on a pay-as-you-go or sewer service charge basis, industry should be allowed certain usage of the sewers free of charge. If, however, all connections pay a service charge, the excess flow factors may be disregarded but the method of computing industries' additional contribution to the system, plant and place of disposal, as well as the conditions under which the several characteristics control, are the same and the method of arriving at conclusions may be solved by the same factors in either case.

The toxicity of an industrial waste is an important feature and if the waste is toxic its relative quantity, with respect to its total flow at the sewage treatment plant at any time, is of great importance in predicting the effect which the toxic qualities of the waste may have upon the sewage treatment processes. In large plants, toxic wastes may be admitted in relatively large quantities, whereas similar quantities discharged to smaller plants might completely destroy biological processes.

Industrial wastes must be scrutinized and examined as potential destroyers of sewers. Here again the amount of waste which may be admitted to a sewer is a function of the total quantity of other sewage flowing in the line. Any waste which is destructive to the sewers should be admitted with caution and certainly never in such quantities as to imperil the life of the structure.

If the treatment plant effluent is to be used for irrigation, care must be exercised in the admission of salts which are toxic to plant growth. The commonest of these are the borates and chlorides. Borates in very small quantities are toxic to citrus growth, while an unbalanced sodium radical tends also to reduce the fertility of the soil and in some cases destroy it for agricultural purposes.

Shall an industry which connects to a sewer system be required to pay a capital cost for the connection, equivalent to the cost of its required system plant facilities; or shall the plant be constructed by the community on an *ad valorem* or some other equally applicable tax basis and a sewer service charge be made to the industry as and when it connects, such charge to be for operation costs alone?

No fixed rules applicable to all situations may be propounded to answer these questions. The committee is of the opinion that the community as a whole should finance the construction of a sewer system as well as the treatment and disposal works, otherwise it may be confronted with the perplexing situation of having to reserve to the industries their capacity rights, regard-

less of the community's increase in population or other circumstances which may increase the sewage flow and dictate the construction of new works or extension of the old.

Whatever means are chosen, it would seem that the construction of public works required to dispose of sanitary sewage and such industrial wastes as may be admitted to the sewer is the obligation of the community as a whole, no matter what means of financing construction or operation are employed; and that the community as a whole should own the public sewage works and have the authority to regulate the quantity and characteristics of flow thereof in any manner most consistent with all of the circumstances involved.

From this it would follow that the construction cost of the works should be spead on *ad valorem* basis over the area designed to use the system unless, of course, all or a part of the bonds sold for construction purposes are self-liquidating and to be repaid or retired from legally imposed service or rental charges. The committee is more inclined than not to believe that construction and operation charges should be distinct and separate and that no industry should be called upon to construct a definite portion of a sewage treatment works unless it is assured that the proportion of the capacity which it is purchasing is reserved for its use as long as the plant continues in operation.

THE OPERATOR'S CORNER

CIVIC LEADERSHIP AND PUBLIC RELATIONS

A leading Georgia educator recently informed a state group of water and sewage works operators that it was essential that they assume places of leadership in their communities, not only from the standpoint of their own welfare and advancement but to develop public consciousness of the importance of sanitation and health functions in the achievement of maximum industrial and economic advancement by the state. This sage advice, which is essentially the theme of this fourth and final "editorialette" on public relations, is worthy of adoption by any sewage works manager in or out of Georgia.

Civic leadership can come only from prominent participation in civic affairs. A superintendent who can manage his departmental affairs capably can do other things capably and he should give a reasonable amount of his time, energy and ability to community activities not directly akin to his "bread and butter" job. By a reasonable amount is meant only a part of that remaining after the requirements of "the job well done" are fulfilled.

A public service can derive "personality" from the individuals who perform it. "Who is he?" and "What does he do?" are the first questions brought to mend when attention is directed to one who is active in his community. It is just as much to the advantage of a public employee and his department to be represented in civic affairs as it is for any business man. A survey of any community will reveal that the most successful business and professional people are those who have earned good will in this way.

Every sewage works superintendent should belong to a local service club. This will inevitably lead to opportunities to address his own club, and others, on the local sanitation facilities or on other public health matters. City planning committees, church affairs, charity drives and educational functions are omnipresent activities. One's own interests, such as music and sports, may offer opportunities; at least two prominent Midwestern plant superintendents have attracted favorable public notice through symphony orchestra work. Another was recently honored for activity in his local chamber of commerce.

For obvious reasons, activities of a political nature have no place in this picture. It is unfortunate that the patronage and spoils systems constantly lurk as menaces to those in public employ, civil service or not. Municipal political intrigue and efficient public service are not miscible, and they should be divorced absolutely.

And so the "Corner" presents its formula for a complete public relations program. Into the primary vehicle, viz., performance of the sewage works service as efficiently and economically as available facilities permit, is intermingled the important secondary ingredients: personalized courtesy, constructive publicity and participation in civic affairs. From the balanced combination of these elements will derive public appreciation, respect and good will—all goals that are well worth attaining.

W. H. W.

ACID IRON WASTES AND DIFFUSER CLOGGING AT ELYRIA, OHIO *

By James R. Collier

Superintendent of Sewage Treatment, Elyria, Ohio

When the Elyria plant was placed into operation, acid iron pickling wastes were received which put more than 100 p.p.m. Fe into the raw sewage. A considerable portion of the iron was in solution.

After the source of the pickling wastes was definitely determined, the contributing manufacturer was consulted and arrangements were made to exclude them from the sewer system by diverting them to an abandoned sandstone quarry situated on the mill property. This arrangement was satisfactory for a number of years but, finally, the wastes seeped back into the sewer system through interstices in the rock strata. Ground water levels are sufficiently low in the dry summer season to prevent appreciable leakage of the wastes to the sewers but, during the wet spring months, they enter the sewers in considerable volume.

Even when received in this indirect manner, the wastes are decidedly acid and still contain much dissolved iron. By the time they reach the plant, most of the acid has been neutralized by the normal alkalinity of the sewage, but the pH of the raw sewage is frequently less than 7.0. At such times, the low pH value prevails through primary treatment and when the iron-bearing sewage reaches the aeration tanks, the contents of which are normally at pH 7.4 to 7.6, the dissolved iron is abruptly precipitated. Much of this precipitation takes place in the porous surfaces of the diffuser plates in the influent channels to the aeration tanks and in the aeration tanks themselves, resulting in restriction of the flow of air through the plates.

On several occasions, deposits of precipitated iron 6 or 7 in. deep and extending 15 to 20 ft. into the aeration units have been removed from the floor at the inlet end. Such an accumulation has occurred in only one week.

During the past year, the Elyria plant was assaulted by the most acute difficulties of this kind yet experienced. Drastic action was required and an unusual method of securing relief was adopted.

Secondary treatment is omitted at Elyria during the winter and early spring months and, as usual, the aeration tanks were placed in operation late in May. This was at a time when leakage of the pickling wastes into the sewers was quite heavy. Although the diffusers were all cleaned before activated sludge treatment was begun, they immediately began to clog with the result that air pressures increased sharply. The increasing pressure soon reached a critical point because the compressors are of the centrifugal type.

In an attempt to remedy the condition, the aeration tanks were shut down one at a time and the plates in the influent channels, being the ones most seriously affected, were cleaned again by spauling of their surfaces. This procedure was repeated three more times with satisfactory recovery each time but, because of the continued presence of the pickling wastes, critical clogging of the plates soon recurred.

Since nothing permanent in the way of a remedy was being accomplished by conventional practice, during the next shut-down two 7/64-in. holes were drilled through each diffuser plate in the influent channel. This greatly eased the pressure but as an increase again took place the tanks were again shut down and a third 7/64-in. hole

* Presented at 19th Ohio Conference on Sewage Treatment at Columbus, Ohio, on October 31, 1945.

was drilled in each influent channel plate. It was not, however, until the tanks had been shut down once more and two 7/64-in. holes drilled in each effluent channel plate that air pressures were stabilized at a point not critical to the operation of the blowers.

Strangely enough, there were no apparent adverse results in the way of purification efficiency as a result of the altered method of air application. Later, the flow of acid iron wastes to the sewers abated with the onset of dry weather and receding ground water levels.

Next spring it is planned to install a new set of diffuser plates and, in an effort to preclude the possibility of such heavy shock loads of the troublesome wastes, an agreement has been reached with officials at the pickling mill whereby the liquor will be worked down to a lower acid content (1.5 per cent) before dumping. The waste is also to be treated with lime as it is discharged to the abandoned quarry.

DIGESTER GAS EXPLOSION AT MONROE, MICH.*

By Arthur J. Jennings

City Director, Monroe, Mich.

The attention given in the program of this meeting to safety and protective measures pertaining to sewage works operation is most commendable. The need for such information was forcibly emphasized by the explosion that occurred in 1944 at the Monroe sewage treatment plant and it is hoped that the contents of this paper will be helpful in preventing similar accidents elsewhere.

Monroe is a city of approximately 20,000 population located in the southeast corner of the state. The sewage treatment plant serving the city was designed by Shoecraft, Drury and McNamee. The sewage contains a large percentage of industrial wastes and is carried by gravity from the lateral sewers to trunk line sewers adjacent and parallel to the river, and thence to the sewage treatment plant approximately one mile east of the main portion of the city. The treatment plant affords primary treatment and the effluent is discharged to the River Rasin after chlorination.

* Presented at the 21st Annual Meeting of the Michigan Sewage Works Assn., held at East Lansing, Mich., on March 18–21, 1946.

Results of Explosion

On October 4, 1944, at 11:06 P.M., there occurred an explosion at the sewage treatment plant. At the time, there was one operator at the plant and he had just made a routine investigation of the boiler room and had returned to the office. During his investigation he had checked the oil in the gas engine and the operation of the boiler, and had detected no gas odor. The building, constructed of reinforced concrete below the ground level and of brick masonry above grade, faces south with its laboratory and the office at the southern extremity. The sewage pumps are at an elevation approximately 18 ft. below the office floor level and the boiler room is approximately 8 ft. above the pump room. The boiler room is connected by a tunnel leading directly to the valve house between the two digesters, located at the east side of the building.

The time of the explosion was noted by the local telephone company because the blast removed a receiver which caused them to investigate. Also, the plant operator coming to work for the 11:30 P.M. shift, was approximately

½ mile west of the plant when the explosion occurred and when he arrived he found the attendant suffering from shock and a cut over the eye. Fortunately the operator received no serious injuries and was able to return to his regular shift in about a week's time.

The effects of the explosion, as manifested by earth tremors, rattling windows, etc., were noticed throughout the city for a distance of approximately 3 miles west of the plant.

Emergency Procedures

Supt. James Godfroy and the writer arrived at the plant at approximately 11:20 P.M., and immediately cut all electrical service to the plant, removing thereby the possibility of any secondary explosion due to broken gas mains or other conditions resulting from the first blast. The flood pumping station, located approximately one mile west of the plant, was put into operation and this dewatered all the sewers in the main part of the city by discharging the sewage directly into the river. Portable pumps were placed immediately west of the plant and the sewage pumped directly into the river, relieving the eastern section of the city. There were no complaints or other indications that any basements became flooded because of the incident.

The next day the power service into the plant was checked, temporary lines to the sewage pumps were constructed and, inasmuch as there was no damage done to these pumps, they were restored to operation. By by passing the detritor and clarifiers it was possible to pump the sewage directly into the river. State health department officials were notified of the incident early on October 5 and were also advised of the temporary arrangements.

Possible Causes of Blast

The explosion, from available evidence occurred in the valve house located on the east side of the main pump building and between the digestion tanks. This is apparent from the manner in which the damages were incurred. Gas apparently accumulated in the valve house building and was ignited there.

Among the theories as to how the gas accumulated were the following:

1. By leakage from a defective gas line.
2. By accumulation in the basement sump of gas-entrained ground water.
3. By escape through a water-filled U-tube located in the gas line.

The U-tubes referred to above were installed shortly after the plant was placed into operation, to replace the automatic condensate traps that did not function satisfactorily. These tubes were designed to have a water column sufficient to resist normal pressures; however, it may have been possible for abnormally high pressures to force the water from the tubes and thus permit gases to escape into the valve house.

Any abnormal pressures should have been released through the pressure relief valves in the top of the dome of the digester. The floating gas holders were not completely filled at the time of the explosion and there is a possibility that the holders could have stuck in the guides and then suddenly disengaged, compressing the gas and causing an instantaneous pressure surge which might have blown the water seal. The lighting fixtures and sump pump motor were not explosion-proof installations and, therefore, either by arcing of the contact points on the float switch to the sump pump, or by defective wiring to the lights, ignition of the gas could have occurred.

Explosion Damage

The force of the explosion followed through the tunnel to the boiler room and into the main pump building. The damages sustained consisted mainly of destruction to the pump building

proper. This building had its entire north wall broken out, the south wall of the transformer room bulged, skylights demolished, and numerous roof sections destroyed and partially removed.

The boilers were either demolished or very severly damaged (Figure 1). These were located immediately ahead of the door entering into the tunnel leading to the valve house. The raw sewage pumps, the sludge pumps, and the office laboratory equipment received little or no damage. The windows of the main building were either all broken out or severely damaged; these were aluminum sash.

The valve house ground floor slab section and the roof sections were damaged by cracking of the reinforced concrete slabs. Equipment in the bottom of the valve house building, such as sump pumps, valves, etc., were severely damaged. Anyone viewing the effects was certain to be impressed by the intensity of the blast causing the damage.

The total estimated damage to the plant was approximately $28,000. Much of the rehabilitation work, however, such as painting, cleaning, straightening and glazing of the aluminus sash, cleanup, etc., was done by the plant personnel and was not included in the general contract covering major repairs.

New Preventive Measures

Many new items designed to prevent a recurrence of this incident were included in the repair contract. These in the main consisted of provisions for positive ventilation throughout the main pump building, the screen room and the valve house. Variable speed fans have been installed in the main

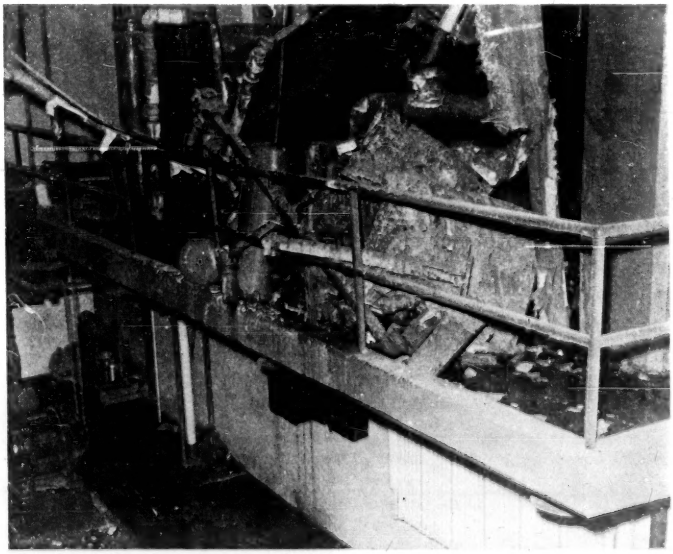

FIGURE 1.—Partial results of digester gas explosion at Monroe, Mich. View shows damaged boilers located in main pump building.

building and screen room, and a fan and blower in the valve house, all of which are constantly operated to remove both heavier-and-lighter-than-air-gases. Furthermore, explosion-proof electrical fixtures, motors, etc., have been installed in these places. It seemed apparent that rather than to depend on gas detectors or some other devices where both the human and mechanical elements are involved, it was advantageous to incorporate positive ventilation throughout the building and especially in those locations where gas would be most likely to accumulate.

A waste gas burner has been installed near the river bank, approximately 100 ft. from the building. Heretofore, the excess gas was dissipated from the top of the main building and it was felt that some gas might be carried into the building under certain conditions of weather and wind.

A gas scrubber or purifier was included among the improvements in order to purify the gas and stop corrosion in the gas heaters, engine and boilers. An improved type of flame trap was installed on the gas piping between the gas purifiers and the digesters; also, the newest type of automatic gas control was provided at the gas-fired boilers.

The repairs to the plant have been completed and Supt. Godfroy has done a splendid job by keeping the cost down in performing much of the work with the regular plant personnel.

Insurance Coverage

Fortunately, most of the loss was covered by insurance. The "general form" policy contained an inherent explosion clause covering the buildings. The office equipment and other equipment not a part of the functional operation of the plant, however, was not covered.

The insurance on this plant has been changed from a general form fire and wind policy, including the inherent explosion clause, to an extended coverage type. The extended coverage policy gives greater protection in the event of a loss.

Recommendations

The following suggestions for explosion prevention are offered on the basis of the experience described above:

1. Determine all possible sources of gas leakage and locations at which gas might accumulate.

2. At these points provide control measures such as gas indicators and/or positive ventilation. The Monroe plant originally had wind-driven ventilators installed at these points but the explosion occurred on a still heavy night when the wind ventilators apparently were not removing the gas.

3. Check electrical wiring and pump motors for defects and arcing contact points. It is deemed most advisable to install explosion-proof fixtures and positive wiring at all vulnerable locations.

4. Induce positive ventilation in buildings so that they will be protected under all atmospheric conditions.

5. Caution plant personnel on safety measures such as smoking, proper operation of valves, etc.

6. Check the amount and type of insurance so that there will be adequate coverage from any type of loss.

AIR DIFFUSION PROBLEMS AT CLEVELAND'S SOUTHERLY PLANT*

By G. E. Flower

Superintendent, Southerly Sewage Treatment Plant, Cleveland, Ohio

The Cleveland Southerly sewage treatment plant has two aeration tanks, each having an inlet and outlet channel with an around-the-end baffle. The inlet channels are so constructed that they may be used to admit the settled sewage and return sludge at the inlet, or they may be used for reaeration of the return sludge before admixture with the sewage at various points closer in the aeration channels. Each tank is 157 ft. 6 in. long, 25 ft. wide and 15 ft. deep, and is designed for an aeration period of 1.5 hours at a rated capacity of 22.5 m.g.d., with 25 per cent sludge return. The mixed liquor flows to two Dorr Sifeed clarifiers, each 130 ft. in diameter and 12 ft. deep. Each clarifier affords 2 hours detention at the above design rate.

Compressed air is furnished by two Roots-Connersville blowers, each with a capacity of 10,000 c.f.m. and direct connected with two 400-h.p. Cooper-Bessemer sewage gas engines. These engines are operated alternately so that one unit is kept in reserve.

Aeration Tank No. 1 was equipped with approximately 1,500 Aloxite porous diffuser plates of No. 40 permeability. These plates are mounted in aluminum holders, located on the bottom of the tank. Aeration Tank No. 2 was equipped with approximately 1,500 porous carbon teardrop diffuser tubes of No. 20 grade, and with a permeability rating of 26.0 c.f.m. ± 10 per cent at 2 in. pressure, and a submerged rate of 6.0 c.f.m. at a differential pressure loss not to exceed 7.2 in. The tubes are of the lift type and are located, when in use, about 2 ft. above the bottom of the tank.

The aeration units were placed in service in October, 1938. In the latter part of November, 1938, Tank No. 1 was drained to repair a gate valve, and during that period the plates were brushed and hosed off. In the early part of January, 1939, clogging of the tubes in Tank No. 2 became very serious, causing excessive air pressure at the blowers. The tubes were lifted and washed with a water hose. Normal operation proceeded for a few days when the pressure at the blowers again became excessive and the same procedure of cleaning was repeated.

Analyses of the settled sewage influent showed an average of about 100 p.p.m. of iron, and occasionally amounts as high as 400 p.p.m. were observed.

It was thought that if the rate of air diffusion through the tubes was increased, there would be less tendency for the deposition of iron oxide on the tubes. All of the 1,500 tubes were, therefore, removed and cleaned with acid, and only 700 tubes replaced. The rate of diffused air through the tubes was thus increased from 2.5 c.f.m. per tube to 5.0 c.f.m. per tube. Analyses of the coating on the tubes showed 1.5 to 2.0 grams of iron on each tube before they were cleaned with acid.

In the meantime, the Chicago Pump Company and the National Carbon Company were conducting tests on various types and shapes of diffusers. These results showed that clogging occurred on any kind or shape of diffuser that was used.

Tank No. 2 was placed in service, and, after a very short period of operation, the tubes started to clog again.

* Presented at 19th Ohio Conference on Sewage Treatment at Columbus, Ohio, on October 31, 1945.

The tubes were raised and cleaned with acid, and before putting them back in service they were coated with a water insoluble grease. After this treatment, the tubes functioned satisfactorily for about seven months before clogging again developed. The tubes were removed and cleaned with naptha and acid and were again treated with grease after which they operated for about three days before clogging again developed. The same cleaning procedure was repeated several more times, but the clogging action always developed after a short period of operation. The practice of greasing the tubes was discontinued as it did not appear to be of any advantage.

In the meantime, many of the hoisting cables that were used to raise the tubes had corroded at the surface level of the sewage, causing them to fail at this point.

The Aloxite plates in Tank No. 1 were removed and acid-cleaned quite a number of times during the same period that difficulty was being experienced with the carbon tubes.

The most serious clogging of the plates and tubes occurred during the year 1939, when the iron pickle wastes in the sewage were excessive. Since that time, the diffusers have functioned more satisfactorily so that the practice now is to clean them twice a year—in the spring and in the fall.

The last summer, the aluminum plate holders in Tank No. 1 had deteriorated so badly by corrosion that it was thought advisable to remove them and replace the plates with perforated pipes. The pipes have been in service for about two months and do not show any indications as yet of clogging. Routine tests show from 1.5 to 2.5 p.p.m. of dissolved oxygen in the mixed liquor when using these perforated pipes.

MONSIEUR LE VIDANGEUR

By J. E. McKee

Engineer, Office of Thomas R. Camp, Consulting Engineer, Boston, Mass.

On D-Day, the 6th of June, 1944, troops of the First U. S. Army stormed ashore into Normandy, prepared, it was thought, for all eventualities. To meet the threat of an enemy gas attack, they had gas masks, impregnated clothing, and decontaminants; to ward off air attacks, they had anti-aircraft guns and barrage balloons in concentration never before witnessed; to control the civilian population, they had Civil Affairs officers, proclamations, ordinances, and even French liaison officers; to re-establish civilian commerce, they had newly printed French francs.

With an emergency associated with the pursuits of one individual, however, they had failed to reckon. That individual was *Monsieur le Vidangeur*.

Before proceeding with this dissertation on military history, it might be well to bring the reader into rapport with some of the terminology and customs of the shores that were being invested. The professional title, *M. le Vidangeur*, is derived from the French word *vidanger*, meaning "to empty"; hence a *vidangeur* is "one who empties." Unfortunately, we have no English word that expresses precisely the same function with the same finesse. The nearest descriptive American term is the slang expression "honeydipper." The vehicle used by the *vidangeur* to haul away the fruits of his labors is known as the *voiture de vidange*. Again the literal translation "empty-

ing wagon" fails us, but we may call it the "honeywagon."

As to the more quaint customs of Normandy, it seems that interior toilets and waterborne sewage systems are practically unknown, except in the downtown section of Cherbourg. Even there, only about one-third of the population is served by sewers, the remainder having to resort to privies. The Norman privy, however, differs from the common-garden variety, Chic Sale-designed, U. S. rural model. Unlike its American cousin, a wooden structure built over an earthen pit and moved whenever the pit becomes full, the Norman model is a permanent structure, generally made of stone, annexed to the house, and set over a masonry vault. In due course, the vault fills and must be emptied. Many vaults have no man-hole; they are accessible for emptying only through a small opening into which a suction hose is inserted. It is apparent, therefore, that the job requires special equipment, to wit, a hose, a sludge pump, and a tank for hauling the material away. It also requires an operator trained in his profession, and possessed of a special olfactory sense or, should it be said, lack thereof.

To return to the invasion, the dilemma with which the First U. S. Army was faced shortly after D-Day arose from the fact that all of Normandy (except Cherbourg) and most of Brittany were served by only *one vidangeur*, M. Louis Legros. That other enterprising men of France did not offer competition may be attributed to the special qualifications required of the operator, or to the opprobrium connected with the profession. Or it may have had something to do with the system of cartels and government-controlled monopolies. Whatever the reason, there was in pre-war Normandy only one *vidangeur* and, unfortunately, he was not available during the first six weeks of the campaign. His absence did not mark him as a collaborator, but rather as a man of engineering genius and business capacity. To serve Brittany as well as Normandy, he had based his operations in the town of Avranches, at the southwestern edge of the Cotentin peninsula. From there, he operated a fleet of seven honeywagons, on the principle of economic haul and centralized control. Inasmuch as the Germans held Avranches prior to the St. Lo break-through, they also held *M. le Vidangeur*, Louis Legros, and thereby the key to sanitation in the peninsula.

Within two weeks after the initial landings, complaints and pleas for assistance began reaching the G-5 Section of First Army Headquarters. They came first from the towns of Carentan and Isigny, because they were the largest and most strategic communities and harbored the greatest concentration of troops. Soon, however, every village faced the same problem. The tremendous build-up of American forces in the beachhead soon caused the troops to outnumber the indigenous population by 5 to 1. Since no G.I. will use his intrenching tool if he can find a more comfortable and well-established facility, every accessible privy was soon filled to overflowing. The name of M. Louis Legros was on every lip. Thought was given to having the French Forces of the Interior smuggle him through the lines, but that idea was discarded when it was realized that without his equipment, *M. le Vidangeur* would be helpless. Another school of thought advocated bringing sludge pumps from England, but with the critical trans-channel shipping situation and the time required to schedule emergency equipment, that scheme was recognized to be impractical.

Hopes rose about a week before the St. Lo break-through when there was discovered among the ruins and debris of ravaged Montebourg one of M. Louis Legros's *voitures de vidange* in surprisingly good condition consider-

ing the destruction with which it was surrounded. D-day had caught it on its bi-weekly excursion up the peninsula, and there in Montebourg it had been abandoned. The operator had fled or been killed. Swinging rapidly into action, Civil Affairs officers and men, assisted by First Army Ordnance, soon had the *voiture* rolling and on its way to Carentan. Complications arose, however, when the *Maire* could find no one to operate the equipment.

While that problem was being resolved, the picture was altered by the St. Lo break-through. Hot on the heels of the 7th and 8th Corps assault troops who swept down the peninsula went a sanitary engineer of the First Army in search of M. Legros. At Avranches, it was learned that M. Legros had fled during the bombardment to a farm about 20 kilometers away. After him went the sanitary engineer, over back roads that had never before felt the wheels of an American jeep.

The scene that was transacted at that farmhouse refuge was one of joy and tragedy. M. Legros wept with joy when he learned that his *voiture* at Montebourg had miraculously escaped serious damage. His wife, *La Femme du Vidangeur*, and his daughter gazed with amazement at the fabulously wealthy Americans who drove a jeep, carried K rations, and possessed in their pockets apparently unlimited quantities of candy and chewing gum. The Americans agreed to supply M. Legros with sufficient gasoline and vehicle maintenance to enable him to operate his essential trucks; M. Legros, in turn, promised to assemble his workmen and get busy on his backhouse backlog as quickly as possible.

The outcome of this episode will probably remain forever unknown to the author. A few days after *M. le Vidangeur* was liberated, the First Army was wheeling across northern France and into Paris, leaving Normandy and *Monsieur le Vidangeur* to be handled by rear-echelon service troops.

MAINTENANCE PROBLEMS IN A LARGE SEWAGE TREATMENT PLANT*

By V. Anderson

Engineer of Sewage Treatment, Detroit, Mich.

The Detroit sewage treatment plant has now been in operation six years. In that time a large variety of maintenance problems have been encountered. These problems, of course, are similar to those of any sewage treatment plant, but because of the size of the Detroit plant, many of them become serious enough to require special study and special remedies. By special study is meant laboratory tests and analyses. Special remedies may involve use of some new material or a new use of an old material.

* Presented at 21st Annual Meeting, Michigan Sewage Works Assn., East Lansing, Mich., March 18-20, 1946.

Corrosion Problems

The ever-present problem around every sewage plant is corrosion of metal parts. This is troublesome enough where sewage alone is handled, but in portions of a plant where chlorine fumes are present or vapors of ferric chloride are added to condensed moisture, severe corrosion occurs very rapidly.

The piping in and around the chlorinators is frequently subjected to chlorine attack. The inside of a 12-in. vacuum line from the filters and the interior of the moisture trap tanks were found to be deeply pitted from the corrosive

action of ferric chloride vapors. The inside of a cold water tank also showed signs of advanced corrosion. To all of these problems the question was the same: "Is there a single paint on the market that can produce a flexible insulating film between the metals and the corrosive agents without itself being attacked by these agents?"

Various recommended paints were given laboratory tests to determine their fitness for this type of service. Some stood up well for some tests but failed in others. Finally, a certain synthetic resinous paint was run through the various tests of acids, alkalis, ferric chloride, oils, gasoline, cold water and chlorine. Of all paints tested this one stood up best.

This paint has been adopted as a standard coating wherever severe corrosion is likely to occur or in places difficult to reach or to inspect frequently. The best job is done on a sand-blasted surface but it also has been used over a well cleaned wire-brushed surface with good results. Certain precautions are necessary with its use in confined areas such as the inside of tanks because the solvents are highly volatile and inflammable. The painter should wear a suitable mask while working in a tank. Adequate ventilation should be provided at all times in areas where this paint is being applied.

This paint was brought to attention a year ago. After passing the laboratory tests it was applied in several areas where actual usage tests could be observed. Up to the present time the applications that have been inspected appear to be as good as the day they were applied. No sign of corrosion has developed; no softening, peeling or cracking is visible. The unusual properties of this paint suggest new uses every day.

Digester Maintenance

During the summer of 1945 the digester was taken out of service for its first interior inspection and cleaning since it was started in 1940. From experiences of other plants, there was anticipated a serious maintenance problem in the corrosion of heating coils, their supports and other metal parts in contact with the sludge. The possibility of cathodic protection had been investigated for use if conditions were found to be severe enough to warrant the installation. Fortunately, when the digester was emptied, most of the metal work was found to be covered with a protective scale, lime-like in appearance and about 1/32 in. thick. Underneath this scale the original lead and graphite paint was intact and perfectly preserved. The metal underside of the floating cover was coated with a film of oil and showed no signs of corrosion, although the original red lead paint was gone in many places.

The digester normally contains a layer of oil from 2 to 4 ft. thick on top of the sludge. The oil furnishes excellent protection for the metal at this point and also provides a pervious strata through which the gas bubbles can readily escape. The maintenance problems thus dwindled to a job of removing the collected scum from the heating coils and returning the digester to service. It was also learned that aside from cleaning the heating coils the digester need not be taken out of service for another 10 or 15 years.

Mechanical Maintenance

Another ever-present maintenance problem in a plant where there is much mechanized equipment is the continual repair or replacement of worn parts. The gritty nature of the material handled accelerates wear many times over the normal amount. In many instances there appears to be no other solution but to replace the worn parts. Many parts such as pump impellers and "screwpellers" that are not too badly worn can be built up by welding and then ground to size. Worn shafts can be built up by metal spraying and

grinding down to dimension. The bearing ring on a large filter head valve casting was recently sprayed with a bronze wearing surface and then turned down to size. This metal spray gun was purchased within the last few months and it is planned to use it to apply metal protective coatings on areas where paint is not suitable because of temperatures above 212° F.

Chemical Piping

Another new material which is being used more extensively in the conveying of ferric chloride is plastic tubing and piping. This material is highly resistant to many acids and alkalis and stands up under ferric chloride usage as well as rubber lined pipe. The tubing is translucent so the ferric chloride is visible as it flows through. The tubing is quite flexible and can easily be joined with plastic flare type fittings. The pipe can be threaded much like iron pipe, but many turns, tees and ells can be made simply by heating the ends of the pipe and butt welding the joint.

Conveyor Belts

An item of considerable expense in the first years of the plant's operation was the replacement of conveyor belts. The original belts were made of natural rubber. The grease and oil in the grit and sludge cake handled on these belts soon swelled up the rubber until bubbles appeared and joined together. The top surface then came loose from the carcass of the belt. The exposed canvas soon rotted or wore through, making replacement necessary.

This problem was solved by the use of a thicker synthetic rubber on the wearing surface of the belts. This material is effected very little by grease or oil and thus has increased the life of the conveyor belts as much as 75 per cent.

Another means being used to prolong the life of the conveyor belts is to decrease their speed of travel. Originally these belts traveled at a rate of 150 ft. per min. Many of them have been reduced to 110 ft. per minute. Since much of the wear on these conveyors is due to the friction of the rubber wiper at the head pulley, the life of these belts should be increased about one-third.

Incinerator Hearths

The repair of the hearths of the incinerators requires numerous special shapes of fire brick. Occasionally there is a shortage of a certain shape and substitute one is made of a castable high-temperature cement. Experience has shown that these castable shapes hold up as well as the others and in some locations even better than those made of fire clay.

Conclusion

The program of maintenance at the Detroit plant is based on the premise that an ounce of prevention is worth a pound of cure. Much of the equipment undergoes periodic inspection. The sludge pumps, for instance, are checked every three months for shearing bar clearance and bearing wear. Large sluice gates are operated every six months. The windings of the large motors are meggered every six months to check for any weakness which may be developing in the winding insulation. By following such a program it is possible to keep most of the equipment in efficient running order at all times.

BARK FROM THE DAILY LOG

By Walter A. Sperry
Superintendent, Aurora (Illinois) Sanitary District

March 4—The Aurora plant originally had ten sludge drying beds, each 40 by 125 ft., giving a total area of 50,000 sq. ft. and providing about 1 sq. ft. per capita for the present connected population. In 1940 eight additional beds were added, bringing the total area up to 96,250 sq. ft. or about 2 sq. ft. per capita. Now we have sufficient area to discharge the two secondary digesters twice before it becomes necessary to clean any beds. In 1945 the period of filling the digesters averaged 51 days and ranged from 30 to 69 days, each digester having been discharged seven times.

During the past few weeks, the entire sludge bed area was resanded. The sand was obtained from a nearby gravel washing plant and is a discard of no commercial value. For us it seems ideal. A total of 650 cu. yd. of this sand was laid down on the beds at $1.59 per cu. yd. We have always felt that the grading of a sand for sludge bed use was an important item that is too often neglected. In many cases the sand selected is too fine-grained. This sand was carefully sampled and gave the following average sieve analysis:

Sieve Mesh	Opening (mm.)	Per Cent Passing
100	0.197	3.3
80	0.247	4.5
60	0.357	10.2
40	0.456	24.2
30	0.650	31.7
20	1.04	58.3
10	2.08	79.1
4	5.19	98.8
On 4	—	100.0

From these data, the effective size is determined as 0.352 mm. and the uniformity coefficient as 3.21. The specific gravity of the sand is 2.72 and the void space about 36 per cent.

March 13—Your Logger has a definite conviction that this column would not be acceptable if factual items as the above were not occasionally relieved by the fun spots of the day.

This morning a fire department employee called to ask if the plant truck would not bring along a bottle of "discharged water." In the afternoon Lewis Birdsall and Gerald Hauer, his assistant, of the General Chemical Co. called to make up for a long war-imposed absence. On being told of the incident, Mr. Birdsall flash-punned "Does he mean our'n or your'n?"

March 18—During the summer of 1945 it was necessary to retube the exhaust heat exchanger for the engines. A full account of this operation was given in this **Log** [**This journal, 6,** 1269 (Nov., 1945)]. At the time it was thought to be a good job.

Recently this heater showed signs of trouble, particularly in the amount of water draining from the trap at the bottom. Upon removing the bottom plate we were shocked to find the space nearly filled with iron scale—almost a bucketful. Upon removing the top cover we found that the 16 tubes on the entrance and downside were clear but 9 of the 16 tubes on the up-side and to atmosphere were plugged so tightly with scale that we despaired of getting the tubes clean. It took a day of hard work with iron rods and a sewer tape to accomplish it. Afterwards a spring-type flue cleaner was run through all the tubes, scraping considerably more scale from the tube walls. One tube had split and this was plugged with wood at top and bottom. A good wood plug will withstand a pressure of 125 p.s.i.

The condition we uncovered was unlike anything we had ever before observed, especially within six months of retubing. It was a day or so before we began to feel reasonably sure of the cause. Now we think the trouble was initiated by our delay in replacing a broken thermometer in the shell. This thermometer aided in the control of the temperature in the tubes by means of a throttling and by-pass valve which is intended to hold the temperature at or above 130° F., the "dew point" below which vapors condense. In stacks and other equipment corrosion begins when the temperature drops below this point. It is likely that the temperature in this heater was around 110° to 115° for some time, which is much too low. This is evidenced by the fact that there was not the slightest indication of any scale being blown over from the muffle attached to the heater. The 16 entrance tubes on the down-side were not only open but there was considerably less scale on the tube walls than on the up- and out-side. This meant that the vapors entering the tubes from the muffle at some 500° or 600° F. rapidly cooled on the down-side where vapors began to condense near the end of the down-side tubes and remained in a condensed state the full length of the up-side tubes. The result was severe corrosion.

This story is told in detail to emphasize the importance of temperature control in such apparatus and the serious consequences of disregarding the dew-point temperature of 130°.

March 28—We almost never settle down to begin an important task but that we are interrupted by the jangle of the telephone. Today for instance:

At 9 a.m. a lady's voice informed us that her garbage can was full and what should she do about it?

At 11 a.m. the lady officer of a newly-formed (and still enthusiastic) humane society informed us at length that a truck had crippled a dog somewhere near the plant and would we please find the dog and ease its suffering or, better, take it in (5 miles) to the hospital? (What would you do with that one?)

At 2 p.m. the Fire Department called to say that an automobile had overturned and that we should look out for its tank full of gasoline. (Our thanks.)

At 4 p.m. Mr. George Habermeyer of Yorkville (whom we had not seen for years) called to offer us his 15-year files of the AWWA **Journal**, the ASCE **Transactions** and **Proceedings** and of **Engineering Index.** We had most of them but suggested the library of the local Aurora College. The college promptly and gratefully accepted his offering and we found satisfaction in having been of assistance.

April 2—Speaking of magazines, your Logger, who has for years been mostly a bibliophile when not at work, has since 1910 followed a scheme of magazine binding that is easy, inexpensive, practical and takes but little time. A book binder makes a handsome job but it costs more than most of us care to spend. Journals left loose or tied in bundles are too bulky, are soon lost and do not file well on shelves. Publications such as our own **Sewage Works Journal** are the most authoritative manuals of our profession and should be properly preserved. Here is how we do it:

1. Prepare strong drawing paper backs to which has been glued a strong light canvas or denim cloth backing, all trimmed to proper size.

2. Strip the magazines and remove the binding wires. Leave the full front cover of the January issue and the full back cover of the December issue in place to act as fly

leaves. The stripping greatly reduces the bulk.

3. Assemble the volume with the prepared covers in place between two iron clamps and draw the bolts tight (Figures 1 and 2), seeing that the magazine is squared and true. A good quick substitute for the special iron bars is two narrow boards with screw clamps.

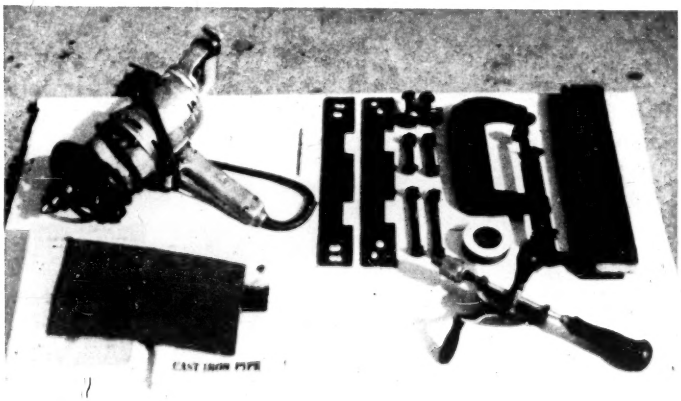

FIGURE 1.—"Stripped" 1945 volume of Sewage Works Journal, with prepared cover, ready for binding. Note metal clamps with three sets of bolts for volumes of varying thickness, also the simpler wood clamp that is equally effective. Either a hand or electric drill may be used; the latter is best.

FIGURE 2.—Metal and wood clamps in place and ready for drilling operation. Note the three finished volumes.

4. Drill two sets of two holes, each about 1 in. apart, properly spaced and located about ½ in. from the back edge.

5. Before removing clamps, tie the volume with four strands of good fish-line, using a darning needle or double strand of fine wire, and tie with box knots.

6. Release the clamps and you have a strong volume well bound.

7. Mark the back with the volume number and year, using a brush and drawing ink and paste on the front cover title of the magazine, as cut from a discard cover.

April 16—Chapter VI of the Paper Mill Story. This chapter reviews the average results of the daily tests for the last six months of 1945 as compared with the average results for the year 1944:

(a) Suspended solids reduced from 1,460 p.p.m. to 969 p.p.m. or 33.6 per cent.

(b) Flow as m.g. per week reduced from 1.25 m.g. to 0.7 m.g. or 43.2 per cent.

(c) Pounds fiber lost per day reduced from 2,760 lb. to 1,245 lb. or 54.8 per cent.

(d) Tons fiber lost per week reduced from 7.3 tons to 2.99 tons or 59.1 per cent.

This was a most gratifying gain. When the results and curves were shown to the mill officials they volunteered the remark that no such improvements would have been made except for the weekly reports and "prodding." The further result of this type of interest and co-operation was a complete willingness on the part of the mill to make further operating improvements that would include the parallel operation of both the Oliver filter and the save-all, to compensate for the addition of a fifth paper machine. There was also included the installation of a curb and float-operated sump pump to catch all the "spills" from the paper machines for return through the save-alls instead of losing them to the sewer, as heretofore. It is estimated that these changes will halve the losses obtained at the close of 1945, in spite of the addition of 25 per cent more board production capacity.

April 20—There are more ways than one to kill a cat. The **New Yorker** reports a taxicab driver who apparently did not own a G. E. Disposall. He had trouble in getting rid of his household garbage until he hit upon the clever scheme of wrapping it in neat bundles and tossing it upon the rear seat of his cab. His fares always slyly managed to steal it. This reminds us that we are soon to have a hotel-size Disposall, on 6-months acceptance trial, to be used as a screenings grinder in connection with a new screen.

April 25—It is again timely to think about weed control. Among the better known weed killers mentioned in the November, 1945, **Log**, used crank case oil gave us the best results for gravelled areas. Usually it can be obtained at no cost from any service station by providing a container. Applied generously enough to saturate the ground for several inches, its effects will last the whole growing season. Also, its effects are cumulative since it does not tend to leach out as does salt and calcium chloride.

One of the new and promising weed eradicators for grassed areas is now being put on the market by the Sherwin-Williams Co. of Cleveland. It is called "Weed-No-More" and consists basically of dichlorophenol-acetic acid. It does not harm the soil, is non-poisonous to man or beast and is not inflammable. Applied as a spray to grassed areas it is said to have a lethal effect on all weeds having broad leaves, such as dandelions, ragweed, poison ivy, dock, plaintan, buck thorn, etc. It should not be applied in excess since it may kill clover and check grass growth. It

comes in concentrated form. One ounce is diluted to 1 gal., which is sufficient to cover 200 sq. ft. Its use and effects have been widely studied with very favorable results according to the **American Nurseryman.**

This may be worth experimenting with, especially where lawns are as badly infected with dandelion and buck thorn as are the Aurora lawns. Later notes will be given on the use of cyanamide and ammonium sulphammate, or "Ammate."

April 30—A personal note. This **Log** has been compiled under the suppressed excitement of an impending wedding. One daughter and two sons are happily married and your Logger is the proud grandpa of seven and one-half grandchildren. Now comes the wedding of the last son!

DIGESTION TANK SCUM

By Walter E. Gerdel

Superintendent, Westerly Sewage Treatment Plant, Cleveland, Ohio

Digestion tank scum, or top sludge, as some prefer to call it, is a rather common problem to a great many sewage treatment plants. Eliminating the cause or controlling the quantity of scum is difficult and sometimes hazardous.

Wisely (1) reported, after making a survey of the problem, that the scum problem exists in at least one quarter of all sewage treatment works employing the digestion process, and that this was a conservative estimate. The writer believes that a much larger percentage of sewage treatment plants are troubled at the present time with this problem, and that as other plants are loaded up to design capacity, they too will be affected. Undoubtedly wartime conditions have also had their effect in creating this problem at some places.

No attempt will be made here to give reasons for scum formation at some plants and lack of this problem at others. The following general factors appear to be of greatest importance in regard to digester scum formation:

(1) Sewage strength and character.
(2) Degree and type of treatment provided.
(3) Digestion capacity available.
(4) Digester chemical condition such as pH, alkalinity, volatile acids, etc.
(5) Digester temperature.
(6) Volume and quality of supernatant removed.
(7) Return of ground screenings to the sewage flow.

Effects of Excessive Scum

The effects of scum formation are many and vexatious, and can be divided into two general categories. The first of these is operational difficulties and among these can be enumerated the following:

(1) Decrease in effective capacity of the digester and shorter digestion time of the sludge.
(2) Decrease in heating efficiency when scum envelopes the heating coils.
(3) Reduction of supernatant forming zone and, consequently, in the amount of supernatant available for withdrawal, with a correspondingly greater volume of thinner digested sludge being produced.
(4) Entire loss of capacity when tanks are taken out of service for cleaning and repairs, along with the additional safety haz-

ards that are always present when an operation of this kind is necessary.

The second general effect of scum concerns extra repair and maintenance work that may be necessary. The more important of these items are as follows:

(1) Damage to mechanical scum breakers.
(2) Structural damage to tank walls and roof.
(3) Sealing off of gas outlets.
(4) Breakage of heating coils.
(5) Caking of heating coils.
(6) Bowing and collapse of structural steel supports within digesters.

As an illustration of the effects of scum, experience is cited with the six 50-ft. diameter floating cover digesters at the Westerly sewage treatment plant of Cleveland, Ohio. This plant has always been troubled with scum, chiefly because of the fact that stockyard wastes comprise a considerable portion of the sewage flow. The paunch manure contained in the stockyard wastes seems to be quite resistant to the digestion process and tends to accumulate as scum.

In the 10-yr. period of 1936–45, inclusive, it has been necessary to pump down and clean out a digester on 25 different occasions. Ten times this was necessary because of broken heating coils. On fourteen other occasions, poor operating conditions, such as scum interference with removal of supernatant or caked heating coils made this advisable. Numerous times after cleaning a tank, the structural steel supporting the inlet sludge piping was found to be in a damaged condition, and on one occasion the entire structural steel support was found totally collapsed and laying on the bottom of the tank. The heating coils have been found with sludge scale approximately ¼ inch thick, a number of times.

Structural damage to fixed cover digesters has resulted when scum accumulations have sealed off gas outlets at Sioux Falls, S. D., and Sheboygan, Wis. (1).

Excessive scum accumulation has, in many plants, either damaged mechanical scum breakers or imposed such a heavy load that they could not be operated.

It can be seen that where scum is a problem, it must be kept under constant observation and given suitable remedial attention to preclude poor operation and possible serious damage to equipment and structure.

Methods of Scum Control

(1) *Elimination of Scum Forming Material*

If some specific material is primarily responsible for the heavy scum formation, it may possibly be eliminated or minimized in quantity by preliminary removal and disposal at the industry at which the troublesome waste originates. Or, if such preliminary treatment is not feasible, the employment of fine screens at the sewage treatment plant may be justified.

Fischer (2) states that digester scum difficulties have been reported to be magnified where screenings are disintegrated and returned to the sewage flow.

(2) *Recirculation of Sludge and Scum*

Sludge recirculation is widely used with many variations and is generally beneficial. Increased gas production often results, which would indicate that scum digestion is stimulated. Recirculation undoubtedly tends to raise the temperature of the scum mass and thereby induces better digestion conditions. The resulting agitation also releases the gas from any gas-buoyed solids and causes some of this material to resettle to the bottom of the tank. Few digestion tanks are equipped to agitate efficiently, recirculate and stir up the scum layers that may accumu-

late in them and, consequently, in many installations, this method of scum control has not demonstrated itself to advantage.

(3) *Scum Removal*

A third general method of scum control is to remove the scum separately and dispose of it. A large number of modifications of this method are in use, which range from manually dipping out the scum from convenient openings to taking an entire tank out of service so that it may be emptied.

Regular routine withdrawals of scum through supernatant lines is being practiced at some plants. Agitation and recirculation are often necessary in order to liquify the scum sufficiently so that it will flow through the available pipe lines. This can be better understood when it is realized that the scum layer may run from 12 to 27 per cent total solids. At the present time at the Westerly plant, routine practice is to withdraw scum once a week from each digester to an open storage tank, from which the scum is removed at later convenience, mixed with sludge, vacuum filtered and the resulting filter cake incinerated. It has been found that the addition of scum improved the filterability of the sludge, although the presence of additional coarse material causes clogging difficulties in the pipe lines to the vacuum filters. Incineration of the resultant filter cake is somewhat more difficult than with straight sludge, because of the higher volatile content and a greater stickiness that produces "balling-up" in the incinerators.

(4) *Ammonia Nitrogen Control*

A relatively new and proprietary method of digester scum control has been described by Schlenz (3). This procedure consists essentially of periodically adding ammonia nitrogen in the form of ammonium sulphate or other convenient ammonium salt to the scum layer, together with recirculation. The quantities of ammonia added range from 15 to 40 p.p.m. of the scum mass. Increased gas production has been reported from a number of installations, and scum layers have been diminished and have been changed from stiff to soft consistency.

Schlenz, in his article, poses the question "Why add ammonia nitrogen to a digesting sludge mixture which is already high in nitrogen?" In answer he cites experience and data from several plants, from which he concludes that adding ammonium salts serves to increase the bacterial potential to utilize cellulose and other material, as demonstrated by increased gas production.

(5) *Increased Digester Temperature*

Increasing digester temperatures for several days has been reported as an aid in reducing scum accumulations. This method does not seem to have practical application where thick scum layers are encountered, however, unless it is coupled with agitation and recirculation so that the scum layer is effectively heated.

(6) *Chlorination*

Chlorination of the raw sewage has been reported to be helpful in preventing digester scum accumulations. At Freeport, Ill., Hutchins has observed that the scum blanket is negligible during the chlorination period, but that a 2- to 3-ft. layer develops during the non-chlorinating season. Wisely (1) notes that this is a similar experience at several other plants.

Conclusion

It is indeed difficult, where a digester scum problem exists, to select a practical method of control and to evaluate various methods as to comparative effectiveness. The difficulty in obtaining good samples and measurements of scum, seasonal variations, the necessity of maintaining full plant operation, the usual lack of a control unit by

which it might be possible to gauge results—all of these add to the complexity of scum control studies. Justified conclusions as to the best control procedures can only come after months of persistent and painstaking experimentation.

Forum Discussion

Question: What is the result when the scum surrounds the heating coils?

Mr. Gerdel: When the accumulation gets that heavy it must positively be removed. We had one digester with such a heavy scum layer that it came down on the coils when sludge was being drawn. The record of inlet and outlet water temperatures immediately showed the effect. Several hours later the digester was charged, raising the scum, and the heat transfer abruptly improved.

Early this year, the inlet and the outlet water temperature differential of two of the tanks dropped to only 11°, whereas it is normally 25 to 30°. By recirculation and actual removal of part of the scum, a gradual improvement was effected until the normal heating water differential was restored.

Question: How do you remove scum from the top of the covered digesters?

Mr. Gerdel: We try to pump scum regularly from each digester, using the supernatant withdrawal openings. The present plan is to select the opening at the bottom of the scum level, where the material is soft, then change to the next opening above, and so on. As pumping continues the material gets very thick—soon reaching 20 to 25 per cent solids. The rate of removal then becomes very slow and eventually reaches the point that it is hardly worth while to continue.

Inventories of the digesters show that the scum mass is very dense at the top. In an 8-ft. scum layer, for example, more than half will contain over 15 per cent solids. No attempt is made to pump out the thickest material—there is not enough time available.

C. C. Hommon (Canton, Ohio)—Something happened at Canton about six months ago that has created a real problem at the digestors. From some unknown source we received tons—four to six, at least—of good clean hog hair! It has formed a regular plastic and defies all efforts to break it up and remove it.

C. E. Bryant (Springfield, Ohio)—Our experience has been that the scum contains a good deal of matted rags and sticks and straw that can be removed with forks, pails and other tools. A digester usually has at least two access manholes in addition to the gas dome, and by lowering the level to a point just below the underside of the roof, the scum will usually move to these places. A considerable amount can be removed in this way but it takes time. This is done about once a year at Springfield and seems to be the only control measure necessary.

Mr. Gerdel—Some plants use a similar method that has not yet been mentioned, that is, the use of a hose stream at convenient openings to break up the scum. This is sometimes done once a week. To see what happens when this is done, we tried it on an open storage tank that had been filled with scum, and found that much of the floating material could be knocked down. Hosing is probably not so effective in a closed digester, where there are only a few small openings. Also, its effect is temporary.

When we find it is necessary to empty a digester, our crew has had so much experience that they can do it in 24 working hours. A special blower of 5,000 c.f.m. capacity is used to purge the tank of gas, and light is supplied by a safety lantern. Plenty of water must be used to soften and dilute the scum but, even then, there is plenty of trouble at the pump.

G. E. Flowers (Southerly Plant, Cleveland, Ohio)—At a plant I visited, a scum control procedure was in use that appeared to be very good. This

operator used a 2-in. pipe with an elbow and another piece about 6 ft. long so that a right angle was formed. This was dropped down between the floating cover and tank wall and turned so that the 6-ft. length was directed into the scum. Supernatant was then pumped through the pipe while it was moved around the periphery of the cover. It appeared that the scum was broken up very effectively in this manner.

A. H. Niles (Toledo, Ohio)—Our practice is similar. The level in the digester is lowered until it is 6 to 12 in. from the roof. The same idea of the bent pipe is used, except that a fire-hose with nozzle is attached to it and in that way a hose stream is directed into the scum until it is broken up.

It seems to me, however, that this discussion has brought out the need for better control of the sewer system to the end that certain wastes are kept out of the sewage treatment plant. Certain industrial wastes, such as the hog hair mentioned by Mr. Hommon, should be disposed of by the industry even if some expense is involved.

As the result of a great deal of study and reference to ordinances in use at other cities, a new ordinance was recently adopted at Toledo that I believe will be most effective. This ordinance provides that no industrial waste shall be discharged to the sewer system without preliminary treatment, which pretreatment may be anything required. In some cases the required pretreatment may actually be nothing but the ordinance furnishes authority for us to require whatever may be desirable in the way of grease traps, sedimentation tanks, screens, etc. The ordinance also provides that where any industrial waste, after pretreatment, imposes an unusual or greater than average operation expense at the sewage treatment plant, the industry responsible shall bear the extra cost of operation.

The latter provision is quite a deterrent to promiscuous dumping. The municipal plant can and should take most industrial wastes but it should not be expected to take some things that are not typical of sewage and that might readily be removed for other disposal at the source. I am reminded of the occurrence at Celina, Ohio, where a local cannery macerated all the spoiled tomatoes and discharged them to waste, instead of disposing of them otherwise. The municipal plant is entitled to protection from that kind of abuse.

Mr. Gerdel—Ordinances are of no value, however, if they are not enforced. We had a serious slaughterhouse waste problem two years ago when a lot of entrails came down to the plant in such quantity that a man had to be stationed at the screen to keep it clear and prevent overflow. A report was made to the city health department but their inspectors had no success at all in locating the offender among the six or eight packinghouses in that area. We finally made a visit to one of them and it must have been a good guess because the troublesome waste stopped coming down.

These problems can be traced down by the health department or any other authority but it takes time and money. Too often the ordinances are on the books to set up the authority but there is no enforcement.

Question—In your study of scum problems did you find any relation between the amount of scum formed and the type of cover on the digester?

Mr. Gerdel—No attempt was made to determine such difference. The problem seems to be prevalent at most separate digestion tanks and Imhoff tanks.

Several instances have been reported where mechanical scum breakers have been damaged in fixed cover tanks and it is possible that this equipment is not sturdy enough to handle a heavy scum accumulation. The angles used for supporting some of the piping in our digesters were 3 by 3 by ¼-in. and they were completely collapsed. It

takes considerable power and strength to shear through a heavy mass of scum.

Question—Several operators here have mentioned the use of hose streams of water to break up scum. Is it a good idea to put so much cold water into the digester?

Mr. Gerdel—It is undoubtedly true that the addition of cold water reduces the tank temperature and interferes with digestion. We always use supernatant liquor, which is at tank temperature, when working on an operating unit. Water is used only when a tank has been removed from service to be emptied.

When water must be used, the amount should be held to a minimum.

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2. Fischer, A. J., "Current Developments and Trends in Sewage Treatment." *This Journal*, **13**, 4, 694 (July, 1941).
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INTERESTING EXTRACTS FROM OPERATION REPORTS

Conducted by LeRoy W. Van Kleeck

Operations Report for the Fiscal Year 1944–1945 on the Sewage Treatment Plant of the City of Marshalltown, Iowa

By T. R. Lovell, *Superintendent-Engineer*

Description of Plant

The plant was constructed during the years of 1939 and 1940. Operation was started during March, 1940. The plant consists of a combination of sedimentation and sludge digestion units for primary treatment followed by activated sludge units for secondary treatment. Design was based on an ultimate flow of 4 m.g.d.

Sewage enters the plant through a manually cleaned bar screen, then passes through two 25-in. comminutors into the pump well. From here, sewage is lifted to inlet to grit channels by use of either electrically or gas engine driven pumps. The sewage then passes through one or both of two grit channels equipped with grit removal mechanisms. The grit and sand thus removed passes through a grit washing process and then is hauled away as fill material. Upon leaving the grit channels, sewage passes to a preaeration tank, with a short detention period, for grease and scum separation. Skimmed grease is drained to a sump and then is pumped directly to the digesters. Upon leaving the preaeration unit, sewage either flows through a chemical mixing tank or flows directly to three combination flocculator-clarifiers with a detention of about 2 hr. at design flow. Flocculators are equipped with conventional type mechanisms and clarifiers have the straight line type of sludge removal equipment. The effluent from these units then flows to a channel to which return sludge from the final tanks is added. This mixed liquor is then conducted to the four aeration tanks by means of two aerated feed channels. At design flow and with a 30 per cent return of activated sludge, these tanks provide an aeration period of about 6.5 hr. The aeration tanks are of conventional two-pass design and are equipped with swing diffuser units with diffuser tubes arranged for tapered aeration. Mixed liquor from the aeration tanks is carried by aerated feed channels to

two rectangular final settling tanks, and is fed into these tanks from both ends. The final tanks have a detention period of a little over 3 hr. at design flow. The final effluent is collected at the liquid surface by a system of multiple weir troughs and is then routed through a partially open chlorination channel to the outfall sewer.

Waste sludge is either returned to the primary tanks by way of the raw sewage pump well or is wasted directly to the sludge concentrating unit. Sludge from the primary tanks and from the concentration tank is pumped to two heated digestion tanks.

Sludge gas produced is used as fuel for one 45-h.p. and two 75-h.p. gas engines, by gas boiler heating of buildings and for gas burning equipment used in the laboratory. For gas storage, there is provided a gas compressor and a cylindrical steel pressure tank.

There were provided vacuum sludge filters for dewatering of digested sludge following proper chemical conditioning with lime and ferric chloride. This process is no longer in use, however, since there is available at the plant site a sufficient area of low ground to permit lagooning of digested sludge for many years to come. It is difficult to estimate the savings that have been made in costs of operation because of this change in operating procedure, since the sludge filtration process was not used long enough to accumulate cost data. Undoubtedly a considerable saving has been effected.

There is also installed equipment for the manufacture of ferrous or ferric chloride from iron scrap and chlorine by the Scott-Darcey process, to provide chemical treatment of seasonal cannery wastes. Chlorine or ferric chloride can be introduced into the various plant units, at any step of the treatment process.

The sewage received at the plant for treatment consists of a mixture of domestic sewage from an estimated 18,000 connected population and industrial wastes from hog killing and vegetable cannery operations. This waste is quite strong and shows wide variations in both volume and strength from day to day and during different seasons of the year.

Cleaning of Air Diffuser Tubes

The air diffuser tubes from aeration tanks 1 and 2 were cleaned and replaced. Tubes from tanks 3 and 4 were cleaned during March. Cleaning was done by placing the tubes in a boiling solution of 20 per cent caustic for 2 hr., following which they were rinsed with hot water. Next, the tubes were submerged in a 30 per cent muriatic acid solution for a period of 4 hr. and were then again rinsed with hot water. The steel rods used in making up the diffuser tube assembly were found to be just as badly corroded as when last examined about a year ago. These rods were scaled of rust, buffed on the wire scratch wheel and then repainted, using this time a zinc chromate steel primer in place of an asphalt base paint. The steel rod nuts were too badly corroded for reuse so brass nuts were substituted.

Location of Comminutor Motors

During the night of May 18, electrical power to the plant was interrupted by a severe electrical storm accompanied by heavy rainfall. The gas engine driven pump did not have the capacity to handle the entire sewage flow and the level of the sewage in the wet well rose high enough to submerge both comminutor motors. One motor was burned out. These comminutor motors should have been located at the main plant floor level, through use of extension shafts, rather than being mounted directly on the comminutors in the well below.

Effect of Clay-Laden Sewage on Activated Sludge Process

During a period following a flood-stage in the river, the sewage contained

considerable silt and clay and the activated sludge process worked beautifully. Dissolved oxygen remained high, sludge index dropped as low as 35 and mixed liquor concentrations as high as 7,800 p.p.m. were carried with return sludge concentrations up to 28,000 p.p.m. It can be seen that addition of clay to control bulky sludge has definite merit, providing a means can be found to add sufficient quantities. The volatile content of the sludge dropped to about 35 per cent whereas normally it is around 80 per cent.

Effects of Canning on Activated Sludge Process

As soon as the squash and pumpkin canning run began, in October, it became necessary that all four blowers be used. It was barely possible, even then, to maintain dissolved oxygen in the mixed liquor at all times. Sludge bulked badly and considerable solids were lost from the final tanks. Operations quickly returned to normal, however, upon the conclusion of the pumpkin run.

Further Difficulties with Activated Sludge Process

December and January, as usual, brought increased quantities of grease due to expanded hog killing and chicken canning operations. Sludge quality deteriorated rapidly; it became very bulky and some solids were again lost from the final tanks. Heavy wasting with applications of chlorine to the return sludge was employed but with indifferent success. From December 1 to January 20 a rapid increase in air pressure, from 6.75 p.s.i. to 8.25 p.s.i. occurred. It was necessary, therefore, to again remove, dismantle and clean diffuser tubes. This was done in the same manner as formerly. As before, there was but little evidence of paint remaining on the diffuser assembly rods. Brass nuts were apparently not affected as yet. It is going to be necessary to replace these rods with a more corrosion resistant material. Apparently the clogging of tubes and the bulking of sludge were both affected somewhat by the increased grease content of the sewage. Air pressure returned to 6.75 p.s.i. after the cleaned tubes were replaced. Toward the latter part of January, chlorine applied to return sludge accompanied by heavy wasting relieved the bulking conditions and the tanks have been operating normally since that time.

Recommendation for Repairs to Broken Sewers

The broken sewers left by last year's flood should be repaired immediately. Damage to the plant, through abnormal abrasion of pumps and underwater equipment still continues. It is very difficult to assess the amount of the damage caused in this way, since the wear is progressive and does not all show up immediately. As an example of the amount of sand carried by the sewage, the average daily removals of sand during March were 49 cu. ft. as against from 8 to 12 cu. ft. during dry weather months, and a daily average over the entire year of less than 10 cu. ft. prior to the sewer breaks. The sand removed consists of the coarser material carried, since the finer sand still goes on through into the flocculators and eventually ends up in the digesters. In this connection, it will be necessary that the sludge digesters be emptied and the sand deposits at the inlets to the digesters removed manually, since this material is too heavy to be drained or pumped out.

Recommendation for Screenings Grinder

A screenings grinder of some type is recommended. Since the screenings consist largely of rags and hog and beef casings from the packing plants, it is necessary that this material be screened out ahead of the comminutors. This material is difficult to shred and

being stringy by nature, considerable amounts of it will pass through comminutor slots endwise, resulting in lowered pump discharge and eventual stoppage of pump impellers, requiring shutdown of pump for removal. The present method of disposal of these screenings is by burial after hauling them up out of the comminutor pit and wheeling them to low ground near the sludge lagoon. This practice was never very satisfactory since the material had to be buried quite thoroughly to prevent odors. Now, our rat colony has increased until screenings are uncovered almost as quickly as they are

TABLE 1. Summary of 1944-45 Operating Data at Marshalltown, Iowa

Item	Average
Estimated population served	18,000
Sewage flow (m.g.d.)	3.05
Raw sludge:	
Total for year (m.g.)	11.4
Lb. dry solids, total for year	4,637,790
Lb. volatile solids for year	2,588,110
Gas production:	
Cu. ft. per lb. volatile solids added	10.36
Cu. ft. per capita per day (est. pop.)	4.08
Cu. ft. per capita per day (pop. equiv.)	1.58
Digested sludge to lagoons:	
Total solids for year (million lb.)	1.46
Total volatile solids for year (million lb.)	0.44
Total grit removed for year (cu. ft.)	2,935
Grit removed per day (cu. ft.)	8.0
Per cent return sludge	39.2
Air for aeration tanks (million cu. ft. per day)	4.85
Power:	
Kilowatt hrs. from engines	923,240
Kilowatt hrs. purchased	419,280
Total power value ($)	18,251.64
Power value purchased	6,491.63
Per cent of power from engines	64.3
Heat used (millions of B.T.U.):	
Engines to digesters	4,094.22
Boiler to buildings	1,167.23
Value of gas:	
For heating ($)	4,328.43
Total for heating and power ($)	16,051.35
Air used (cu. ft.):	
For preaeration per gal. sewage	0.04
Total per gal. sewage	2.16
Total per lb. B.O.D. removed	1,780
Chemicals used (lb.):	
Lime	27,025
Chlorine	3,143
Aeration tank detention (hr.)	6.1
Iowa river data:	
Discharge (c.f.s.)	1,237
Ratio stream to sewage flow	(240 to 1)
Digester temperature, average of both (°F.)	91
Dissolved oxygen (p.p.m.):	
Mixed liquor	2.45
Return sludge	1.45
Mixed liquor:	
*Suspended solids—30 min. settling (% by vol.)	41.5
*Sludge index	166
5-Day B.O.D. (p.p.m.):	
Raw sewage	378
Primary effluent	189
Per cent removal by primary units	50
Final effluent	33
Percent removal by secondary tanks	80.7
Per cent total removal	91.3
Suspended solids (p.p.m.):	
Raw sewage	441
Primary effluent	136
Per cent removal by primary units	69
Final effluent	30
Per cent removal by secondary tanks	78
Per cent total removal	93.2
Volatile suspended solids (p.p.m.):	
Raw sewage	282
Primary effluent	100
Per cent removal by primary units	64.5
Final effluent	23.0
Per cent removal by secondary tanks	77.0
Per cent total removal	91.9
Cost data ($):	
Total plant investment	666,692.18
Total cost of operation and maintenance, year	33,778.20
Payrolls	21,593.26
Materials purchased	4,436.77
Power purchased	6,226.68
Sales and use taxes	221.49
Insurance	1,300.00
Cost of operation and improvements, year	34,740.54
Cost per m.g.	28.57
Cost per capita yearly	1.93
Cost per equiv. capita	0.72

* At 8 A.M. (daily av. for year).

buried. A screenings grinder can be installed at the floor level of the bar screen and the shredded material can be washed directly into the pump well below. It has been necessary to replace the stellite faced combs and all stellite cutter teeth of both comminutors, at considerable expense, this past year. Of more immediate concern, because of the expense involved, is the fact that both of the slotted drums of the comminutors will also require replacement in the not too distant future. This excessive wear can be attributed to abrasion by sand contributed through broken sewers.

Recommendation on Diffuser Tubes and Plates

The purchase of enough diffuser tubes for one aeration tank is recommended. These tubes have all had five years of service, the normal life of the tubes, and due to their brittle nature and repeated handling for cleaning, many of them have been cracked and broken. All tubes in a tank should be replaced at one time to assure even distribution of air. Something will also have to be done with regard to the diffuser plates in the feed channels. These should have been installed in removable type plate holders instead of being cemented solidly in place. It has not been possible to clean them in place and they cannot be removed except by breaking. We are having to use excessive amounts of air through the plates still functioning, to make up for plates that are entirely clogged, in order to keep solids in suspension in these channels. Even this is not entirely successful. It may be cheaper to install new channel diffuser tube assemblies instead of removing old plates and installing new plates in removable type plate holders.

Recommendation on Sand Blast and Metalizing Equipment

The purchase of sand blast and metalizing equipment to permit spraying of corroded underwater equipment with corrosion resistant metals has been authorized. It is believed that this will answer the corrosion problem and will delay for a number of years to come the replacement of this equipment.

Annual Report for the Years 1942–1943–1944 on the Operation of the Ann Arbor, Michigan, Sewage Treatment Plant

By C. Preston Witcher, *Superintendent*

A Summary of Operating Results with Particular Reference to the Mallory Process of Activated Sludge

Previous to 1942 every effort had been made to operate the sewage plant as an activated sludge plant, but with never consistently good results. From every indication, although we were designed to handle 4.5 m.g.d., our limit for consistently good operation seemed to be about 3.8 m.g.d.

At this time the usual methods of activated sludge process control were rather cumbersome and time consuming. Results from tests usually lagged several hours behind the process. In our case this lag was just enough that by the time we knew our process condition, our facilities were often inadequate to bring things back into line. With peak flows up to 8 m.g.d., this meant unpredictable and inconsistent operation.

With increased war flows in 1942 a straight aeration process was used for sewage treatment with no return sludge and double settling. Experiments were also conducted with coagulants in the secondary stage. Variations of straight aeration, with and without coagulants, were continued through July with fairly good success for this type of

treatment but admittedly not on a par with activated sludge treatment—but —we treated all the sewage flow.

In August, 1942, Mr. Mallory was retained by the city to make a study of the plant facilities and to try out his method of process control. It was soon shown that one of the limiting factors for successful operation was return sludge pump capacity.

The plant was provided with two 1-m.g.d. variable speed return pumps capable of providing for 25 per cent of the sewage flow return sludge capacity. For an activated sludge of proper settling characteristics this capacity is sufficient but, when building up a sludge or handling shock loadings of industrial wastes or abnormally high loadings of any character, it is necessary to return at much higher rates. Because of plant pumping limitations, primary treated sewage had to be bypassed to the river from time to time.

Starting on September 9, 1942, we began taking the full flow through the activated sludge process. Shortly after getting into operation we started to notice an old trouble we had always had in the form of sludge rising to the surface of the final settling tanks. Although the scraping mechanism ran at the then conventional speed of 1 f.p.m., we had always felt that the settled sludge was remaining in the tanks too long, becoming septic and rising to the surface. Mr. Mallory's observations confirmed our feelings and on this basis the scrapers were speeded up to 3 f.p.m. This change was the answer to the problem.

Mr. Mallory's control tests, while dealing with the same variables as we have always had, namely, air, sludge concentration and rate of return, interprets them in a slightly different manner. He deals in terms of volumes occupied by the solid material instead of its weight and considers the whole process as a straight physical mixture problem in which it is necessary to keep the solids distributed in the correct ratios and in the correct concentrations. Of paramount importance to us, these tests can be run in half an hour, which enables us to keep an accurate check on the process.

In October, 1942, just when we felt we had the activated sludge process under control and stood a fair chance of a continuous run of successful operation, the gas engine, our main source of air supply, was wrecked. We were fortunate in locating a new engine, but due to war conditions it was the first of June, 1943, before the new engine was finally put into operation.

During the period from October, 1942, to June, 1943, we continued to operate the process successfully with our remaining air supply of 3500 c.f.m. and in May, 1943, handled the largest flow in our history, an average of 6.7 m.g.d. for the month. Admittedly, we had to sacrifice some on B.O.D. removel, but the fact that we were able to keep going at all was a proof of the effectiveness of our new approximations of the process factors involved.

During the summer of 1943, we relocated the 1,000 g.p.m. drainage pump in the aeration gallery and installed a new 1,500 g.p.m. return sludge pump along with the necessary 8-in. return sludge piping. We also took out the porous plates in the aerated channels. These had proved unsatisfactory due to the disintegration of the aluminum plate holders. They were replaced with simple galvanized pipe manifolds using a celluloid capillary tube for the diffuser. They seem to be working out very satisfactorily.

In August and September of 1943, plant scale tests were conducted at the plant, under the auspices of the State Department of Health, to demonstrate the effectiveness of the Mallory system of process control. Sanitary engineers and state health department men from many states were in attendance. The Surgeon General of the United States sent Dr. Ruchhoft of the U. S. Public Health Service as an observer

and to run oxidation studies. This period called for much extra effort on the part of all of us but it was very interesting and brought us many interesting visitors.

Since September, 1942, we have operated consistently and successfully as an activated sludge plant with no bypassing and not a single break in operation. We have consistently handled flows for above our designed capacity along with considerable quantities of greases and oils from industrial plants. We have abused the process by returning large quantities of supernatant sludge from the digesters in an effort to get some results from our inadequate digestion capacity. We are required to operate in an unbalanced condition due to the poor hydraulic characteristics of some of our treatment units. In spite of all of these handicaps we continue to produce an effluent of superior quality day after day.

Table 2 is a summary of 1944 operating data.

TABLE 2.—Summary of 1944 Operating Data at Ann Arbor, Michigan

Item	Average
Connected population, estimated	40,000
Equivalent population, based on B.O.D. loading	50,300
Sewage treated (m.g.d.)	4.8
Gas produced (million cu. ft. for year)	20.17
Gas produced (cu. ft. per capita daily)	1.38
Total tons dry solids removed, year	1,663
Tons B.O.D. removed, year	1,498
Tons digested solids removed	931
Analytical data:	
Suspended solids:	
Raw (p.p.m.)	212
Primary effluent (p.p.m.)	201
Final effluent (p.p.m.)	12
Total removal (%)	94
5-Day B.O.D.:	
Raw (p.p.m.)	226
Primary effluent (p.p.m.)	195
Final effluent (p.p.m.)	20
Total removal (%)	91
Aeration tanks and return sludge:	
Daily flow thru tanks (m.g.)	6.3
Cu. ft. air per gal. sewage	1.1
Average aeration period (hr.)	5.3
Suspended solids in mixed liquor (p.p.m.)	1,900
Daily flow of return sludge (m.g.)	1.6
Suspended solids in return sludge (p.p.m.)	5,620
Per cent by volume of return sludge	33
Dissolved oxygen in final effluent (p.p.m.)	3.7
pH raw sewage	7.9
pH final effluent	7.0
Raw sludge:	
Sludge produced for year (1,000 gal.)	12,500.4
Per cent dry solids	3.0
Per cent volatile solids	81.0
Average temperature of digesters (°F.)	83
Supernatant liquor:	
Per cent total solids	1.6
Per cent volatile solids	71.1
Digested sludge:	
Sludge produced for year (1,000 gal.)	10,035.3
Per cent total solids	1.6
Per cent volatile solids	69.2
Costs of Operation ($):	
Cost of operation and maintenance, total	35,137.36
Cost per m.g.	20.11
Cost per lb. B.O.D. removed	0.012
Cost per capita per year	0.88
Purchased power cost per m.g.	3.08
Equiv. value of power from gas engine	6,727.19
Value of gas per 1,000 cu. ft.	0.40

Annual Report for the Year 1944–45 of the Tri-City Sewage Treatment Plant, Pasadena, California *

By Wm. A. Allen, *Superintendent*

Aeration and Clarification

Considerable replacement of the 2-in. air pipes in the aeration tanks has been necessary during the year. This piping has been in service for many years and practically all of the failures have been at the water line due to the action of the air and water.

* For previous extracts see *This Journal*, **15**, 3, 563 (1943); **17**, 5, 1015 (1945).

Removal of some of the wood baffles in the aeration tanks has been necessary due to the gradual rotting of the wood. These baffles were installed many years ago to eliminate short circuiting. No replacement of these baffles is being made at this time.

Three of the six square clarifiers had to be taken out of service to make temporary repairs to the tank walls on account of leakage. Some walls were found to have vertical cracks as wide as ⅛ in., extending through the wall. This has apparently been caused by uneven settlement of the tanks. Extensive repairs will be needed to recondition both the aeration tanks and the clarifiers.

Sludge Disposal

Disposal of the excess activated sludge through the facilities of the Los Angeles County Sanitation Districts has undoubtedly made it possible to operate the plant without serious difficulty during the present period of overload.

General

Sewage flow rates continue to show an upward trend. Based on population estimates as of June 30, 1945, the per capita contribution averaged 69.2 g.p.d.

In April, 1945, Greeley and Hansen completed a review of needed plant facilities for postwar construction. Their recommendations included the addition of primary sedimentation and some changes in building construction. The matter of increasing the size of the plant additions to compensate for the increase in population and flow, and the possibility of combined sewage and garbage disposal, was left open for a later decision. The possibility of forming a four-city sanitation district and joining with District No. 15 in the ownership and operation of a new sewage treatment plant, as compared with enlarging and continuing the operation of the present plant is being considered.

Table 3 is a summary of the operating data for the year 1944–45.

TABLE 3. Summary of 1944–45 Operating Data, Tri-City Sewage Treatment Plant, Pasadena, Alhambra, South Pasadena, California

Item	Average
Population connected	158,699
Sewage flow (m.g.d.)	10.99
Air used (cu. ft. per gal.)	1.53
Chlorine used (lb. per day)	177
Chlorine used (lb. per m.g.)	16.1
Excess sludge (m.g. for year)	94.41
Analytical data:	
5-Day B.O.D. (p.p.m.):	
Raw sewage	158
Main plant effluent	12
Per cent reduction	92.4
Dissolved oxygen (p.p.m.):	
Main plant effluent	3.8
Settleable solids (ml. per liter, 30 min.):	
Raw sewage	10.4
Main plant effluent	0.11
Per cent reduction	98.9
pH:	
Raw sewage	7.3
Main plant effluent	7.6
Suspended solids (p.p.m.):	
Raw sewage	297
Main plant effluent	24
Per cent reduction	91.9
Volatile suspended solids (p.p.m.):	
Raw sewage	255
Main plant effluent	20
Per cent reduction	92.0
Total operating cost ($)	85,732.32
Cost per m.g. sewage ($)	21.38
Cost per capita connected ($)	0.54

Thirteenth Annual Report of the Division of Sewage Disposal of the City of Toledo, Ohio, for the Year 1944 *

By A. H. Niles, *Superintendent*

Brief Description of Works

The sewage treatment works consists of two Evers Sauvage mechanically raked bar screens, two 40-ft. square Dorr detritors, eight 90 ft. by 10 ft. Dorr traction clarifiers, eight 85-ft. diam. by 29 ft. water depth Dorr digesters with fixed covers, gas collection

* For a previous extract see *This Journal*, **13**, 4, 798 (1941).

TABLE 4.—Summary of 1944 Operating Data, Toledo, Ohio

Item	Average
Sewage flow (m.g.d.)	36.8
Max. flow (m.g.d.)	89.34
Sewage sludge gas data:	
Total gas per month (million cu. ft.)	8,136
Gas used for heating bldgs. (million cu. ft. per mo.)	0.474
Gas for heating digesters (million cu. ft. per mo.)	1.209
Gas used to pump sewage (million cu. ft. per mo.)	2.515
Gas used by engine generator (million cu. ft. per mo.)	1.360
Gas wasted (million cu. ft. per mo.)	2.583
Kw. hr. current generated with sludge gas, monthly	32,797
Screenings and scum (cu. yd. per month)	382
Grit (cu. yds. per month)	90
Digested sludge (cu. yds.):	
From digesters to marsh, total for year	33,780
From digesters to beds, total for year	12,465
Dried sludge removed from beds (total cu. yds.)	2,566
Dried sludge pulverized for fertilizer (total tons)	1,123.17
Cash sales of pulverized sludge (total $)	12,132.68
Chlorine (lb. per day, 4-month period)	3,825
Digester temperature (F.°)	82
Suspended solids (p.p.m.):	
Raw	227
Effluent	103
Per cent removed	54.4
Settleable solids removed (%)	93.2
Sewage temperature (F.°)	62
B.O.D. (p.p.m.):	
Raw	270
Effluent	163
Per cent removal	39.5
Cost of sewage treatment ($):	
Power	127.34
Supplies	13,521.64
Supervision and labor	79,641.77
Total cost	93,290.75
Cost per m.g. sewage	6.92

and stirring mechanisms. The digested sludge is pumped to the glass enclosed sludge drying beds located a mile from the treatment works proper. These drying beds consist of four houses, each containing 12 beds 20 ft. by 162 ft. The final plant effluent is chlorinated during the summer time for bathing beach protection. The plant was designed for 600,000 population in 1950 with a mean flow of 80 m.g.d.

Oil and Grease Problem

Considering the year 1944 as a whole, probably the most significant thing concerning the operation of the plant was the accumulation of oil and grease which had been steadily building up during the previous years. At the present time steps are being taken to construct devices which will remedy this condition.

Gas Engine Operation

More kw. hr. of electricity were generated in 1944 than in any year since the gas-engines were installed. In the 8 yr. which the engines have been operating they have effected a total savings of $107,219.51 which is a little less than three times the original installation cost.

Sale of Sludge

The total sales of Tol-e-Gro for the year 1944 amounted to $12,132.58, the largest amount ever sold in any one year since the plant has been in operation.

Table 4 is a summary of operating data for the year 1944.

TIPS AND QUIPS

"Convention in Print," the attractive brochure of manufacturers' exhibits that was distributed by the Water and Sewage Works Manufacturers Assn. to fill the gap left by the cancellation of national sewage and water works meetings in 1945, has enjoyed a reception exceeding all expectations. No less than 87 exhibits were brought to each affiliate of the Federation in

this small but attractive package—a contemporary example of "mountain moving."

Secretary-Manager Arthur T. Clark advises that a considerable number of the books were returned because of changes in address. Nearly all of these undelivered copies had been addressed to men in military service. Any member of one of the Federation's Member Associations who has not received a copy of *1945 Convention in Print* will be gladly supplied with a copy if he will so request, giving his correct mailing address. Requests should be sent to Arthur T. Clark, Secretary-Manager, W & SWMA, 170 Broadway, New York 7, N. Y.

Annual surveys of industrial sewer connections are effective at Indianapolis, Ind., in minimizing discharges of waste materials that give trouble in the sewage treatment plant. During the years 1942–44, a total of 4113 inspections were made at filling stations, garages, meat packing plants, canning plants, poultry houses, dry cleaning establishments, etc. These inspections revealed 1450 violations of city sewer control regulations—an average of about one violation in three plants inspected. Re-inspections of the most important violations resulted in 569 corrections.

This is an example of what may be accomplished when an effort is made to control industrial usage of public sewers. It is obvious that the number of violations would be much greater if no control was exercised.

New York City offers a variety of interesting sight-seeing trips, but the 1-day tour of the Ward's Island, Jamaica and Talman's Island sewage treatment plants that we took last January tops all others in our experience. It was through the courtesy of Wellington Donaldson, N. I. Kass, G. P. Edwards and Patrick Lafferty that we were privileged to have this first opportunity to see any of the New York plants.

The first stop, at Ward's Island, showed us a plant that was extremely hard-hit by wartime shortages of maintenance labor and supplies, but was nevertheless doing a substantial practical job. Designed for a flow of 180 m.g.d., the plant was taking 200 to 225 m.g.d. at this time. Typical of the maintenance situation was the problem with clogged diffusers at the aeration tanks, where emergency action in punching $\frac{3}{4}$ in. holes in the plates—90 such holes per tank—was required to maintain operation. A contract had recently been let covering replacement of the old diffusers.

There is no sludge digestion at Ward's Island, the primary waste activated sludges being mixed after the latter is concentrated in two final settling tanks, then held in storage tanks until disposal by barging to sea is effected. Your reporter was given the impression that the lack of the usual operation problems associated with digestion was offset by unusual labor problems and the compliance with maritime regulations involved in the operation of the three sludge vessels, each of which was built for this specific purpose at a cost of $500,000. An unusual feature is the provision made for deodorizing fumes emanating from the sludge storage tanks. Huge fans pull fresh air into the storage building at the rate of 15,000 c.f.m., the gas-laden air being drawn through canisters of activated carbon and dosed with ozone before exhausts to the atmosphere.

The Ward's Island plant is soon to be expanded to the extent of 200 m.g.d. of additional capacity—to be built on British soil! The new units will be located on area that has been filled with ballast sand removed from cargo ships during the war.

The Jamaica plant is one of the newer additions to the rapidly grow-

ing family of New York's sewage treatment plants. Designed to treat 40 m.g.d. and operating now at full load, this modern activated sludge plant incorporates the old Jamaica screening works. Even the Riensch-Wurl screens are modernized—with new type nylon brushes! At the time of visit, the plant was being converted to conventional activated sludge treatment from the short-period or modified aeration system under which it had been operated for its first two years of existence. The transition was being accomplished without difficulty and the plant effluent was quite satisfactory.

Since preliminary treatment is by fine screens of sedimentation, the final settling tanks are equipped with peripheral skimmers of unusual efficiency. Another extraordinary feature of the Jamaica plant is the elaborate chlorine building (chlorination being provided for use in sludge concentration and for effluent disinfection in bathing season). Among the safety requirements imposed by city fire department officials are (a) provision for flooding the pit in which the 1-ton containers in use are located, (b) facilities for discharging caustic soda to the pits and (c) equipment for exhausting fumes after neutralization by scrubbing under caustic soda sprays.

Screenings from the coarse and fine screens may either be shredded and sent to the twelve digesters or centrifuged and composted. The city park department holds the screenings compost in very high regard, particularly for use on slopes where its fibrous character prevents erosion.

The digester gas power installation at the Jamaica plant is impressive. Three 1,540-h.p. gas engines are provided, only one of which is operated at a time to generate the electrical energy required for pumping and air supply. The ultra-modern power plant control room and equipment is notable.

Visitors at the Tallman's Island plant will experience their first of many favorable reactions at their first glimpse of the striking modern architecture of the buildings. This 40 m.g.d. "show plant" affords treatment by the activated sludge process and is under the supervision of Henry Roth. The flow received at the time of visit was only 21 to 25 m.g.d. and an excellent effluent was being produced with only half of the units in service.

The immaculate pump and blower building, in which aluminum trim and doors are used most effectively, contains eight gas engines aggregating 3,300 h. p. with the largest unit of 900 h.p. One 450-h.p. engine has been converted to the new "dual-fuel" type, operating on gas or oil fuel as desired and the change from one fuel to the other being accomplished without stopping the engine. The converted engine affords greatly improved efficiency and has been enthusiastically received by the operating staff.

The odor and condensation hazards of the "basement" installation of screens and grit chambers are effectively controlled here by the excellent ventilation system. Painted surfaces in this room showed no effects of condensation whatever and odors were negligible.

Another feature of this building is the provision made for the comfort and convenience of operation personnel, in the form of roomy shower and locker facilities a kitchen and a dining room. The facilities will compare favorably with any found in industry.

The Tallman's Island plant was the only one visited that was not operating at or over capacity and, consequently, there is sufficient personnel to carry on complete maintenance functions. It is also the only plant at which landscaping is complete. The effluent fish pond located at the "center of gravity" of the plant layout, as part of the landscaping plan, will have particular appeal to the visiting public.

A thorough understanding of operation features is reflected in the design of all three plants visited. Design En-

gineer Donaldson is given extra credit by the staff of chemists, however, for the splendid laboratories provided. Each laboratory is laid out for "production line" handling of routine samples, with a complete separate unit for research investigations. The most up-to-date equipment is furnished and every need in the way of storage space, dark rooms, incubator facilities, etc., has been anticipated.

Capt. John D. McDonald, erstwhile superintendent of the sewage works at Springfield, Mass., has been stationed at Pusan, Korea, for the past several months. He is presently on duty in the Army Sanitary Corps and writes as follows regarding sewage utilization in Korea:

"A sewage works engineer would starve here in Korea although actually it is a big industry since excrement is a valuable commodity and very little is 'wasted' to sewer systems. I have some photos of the long lines of ox-drawn vehicles hauling the day's collection back to the farms. It is all done very systematically, being put in straw-stoppered kegs and hauled, six kegs to a cart. In Seoul, they use larger casks, which leak profusely and give the entire city a certain atmosphere. These wastes are stored in what might be termed open digesters—concrete rubble-lined pits with thatched roofs. The 'supernatant' from these tanks is then used profusely for fertilizing. It is only partly digested and the whole country is permeated with this odor of septic sewage. I wish my good friend A. L. Genter could be here for a few days as he could devise a method for elutriating the whole area."

Capt. McDonald was conferred with the Federation's George Bradley Gascoigne Award in 1945 and hopes to be present at the Nineteenth Annual Meeting at Toronto next October to receive his certificate in person.

Supt. John B. Kleven of Fargo, N. D., has had an unusual opportunity to compare operation and maintenance experience with housed and exposed clarifiers. The following is extracted from Mr. Kleven's discussion of clarifier operation at the 1945 meeting of the North Dakota Water and Sewage Works Conference:

"One of the clarifiers at Fargo is outdoors and exposed to all kinds of weather and the other is housed with a well-built and weathertight building, which is heated in winter. Temperatures as low as 35° to 38° below zero have not appeared to hamper in the least the full and regular operation of the sludge collecting mechanism in the outside unit. There has been no significant ice formation on the weirs or in the effluent channels. Frost gathers on the exposed metal parts and around the rim of the trough but not to such an extent that there is interference with operation. Temperature loss in the sewage passing through the tank is never more than 2° F., even on the coldest days.

"Trouble with paint on the metal parts of the outside clarifier is less than that experienced with similar parts of the housed unit. Humidity and confined vapors and gases from the sewage seem to have a 'Roman holiday' at all metal parts of the enclosed tank."

Drs. Jan Smit and V. D. Zee, prominent sewage works authorities in Holland, have both survived the war in that country and are anxious to resume peace time pursuits, according to correspondence received by Dr. Willem Rudolfs. A graphic portrayal of the hardships borne by the Dutch people comes from these letters.

Dr. Smit, well known for his research on activated sludge bulking some years ago, was discharged in 1941 from the staff of the University of Amsterdam for protesting certain Nazi regulations. His home was burned and all of his personal possessions were destroyed or stolen. He says, "Since everyone in town lost everything they had, we did not feel so badly."

Dr. Zee is in charge of the sewage treatment plants at Amsterdam (the largest in Holland). He describes wartime conditions as follows:

"In October, 1944, the gas and electric works stopped for lack of coal. There was no gas or electricity for power, lighting or cooking. Each family received 150 pounds of coal for heating and cooking. We went to bed when the sun set and arose when it became light (the sun sets about 4:00 P.M. and rises about 8:00 A.M. during the winter). Since there was no coal or electricity for pumping, the sewage could not be discharged. When streets were flooded with sewage, arrangements were made to operate the sewage pumps a few hours each day with power from outside the city. There was no light, not even for hospitals.

"The food rations decreased to about 500 calories (400 gm. bread and 1,000 gm. potatoes a week). About 3,000 people in Amsterdam died of hunger and cold. We saved our lives by getting sugar beets and dried ground tulips. Driven by hunger the people went with push carts and on bicycles without tires to the country to barter clothing, jewelry, etc. for potatoes and peas. The minimum distance was 80 km. going and the same distance back, over frozen fields or through the inundated country. The foraging had to be done by women and children and very old men, because all men between 16–60 had to go to Germany to work or hide. Prices of food increased greatly. For curiosity the following figures of food stuffs are given:

	Prices per Kg.	
	1940	1944
Potatoes	$0.02	$ 4.00
Bread	0.12	32.50
Meat	0.50	40.00
Butter	0.95	125.00
Sugar	0.20	65.00
Eggs	0.16	60.00
Milk	0.08	5.00
Cheese	0.30	20.00
Peas	0.18	40.00

'Conditions are much better now as far as food is concerned, but shoes, clothing, etc. are still very scarce. This winter we will have ½ ton of coal; we received already 300 lb."

Halloween pranksters at Richmond, Ind., will be disappointed next October if they attempt to repeat one of their 1945 efforts—unless Supt. Ed Ross has a very poor memory. Last November 1, Ross arrived at his plant to find the inlet sewer and grit chamber almost full of solidified asphalt, the grit collecting mechanism jammed and the sludge collector in one primary tank likewise incapacitated. A local dispenser of road materials, evidently unaware of the season, had neglected to lock the valve on an emulsified asphalt storage tank, which oversight caused him to lose—to a nearby sewer—14,000 gal. of the contents of the tank.

Having no desire to undertake the removal of any more of this material from the grit chambers and primary tanks, Supt. Ross vows that he will check, in person, every asphalt storage plant in Richmond to make certain that the tank valves are locked during Halloween. It is reported that occasional chunks of asphalt were still coming down to the plant at the end of the year.

Wire enamel is another substance that has no place in sewage, according to Chemist Paul Bruner at Ft. Wayne, Ind. A leaking tank car at an industrial establishment lost a quantity of this enamel to a sewer where it converted from a liquid to a plastic state by the time it reached the treatment plant. Results—burning out of the 25-h.p. motor of the screenings grinder.

Supt. Ralph Hoot goes on to tell of the time that a quantity of fuel oil appeared in the raw sewage flow at Ft. Wayne, which oil, when traced up the sewer, was found to be leaking from a storage tank at the gas plant. Upon finding the leak, the investigator made a guess at the rate of oil leakage and roughly estimated the total loss for the period the oil had been observed to have been about 5,000 gal. When the findings were reported to the gas

plant superintendent, he was no less than amazed to find that the actual loss of oil was exactly 5,000 gallons! And thus was one Ft. Waynian imbued with a high regard for the perspicacity of the personnel at the municipal sewage works.

Dr. J. Lynn Mahaffey, Director of the New Jersey Department of Health, has announced that consideration is being given to a plan involving monthly issuance of lists of proposed sewage and water works projects as they are approved by the department. Adoption of the plan depends upon the demand for the service.

Those who desire to be placed on the mailing roster for such project lists are urged to request the service by writing to the Division of Health Education, New Jersey Department of Health, Trenton 7, N. J. The lists will be issued within two weeks of the time the projects are acted upon and should be of considerable value in the coming years of increased public works construction.

Editorial

PUBLIC CONSTRUCTION IN PERSPECTIVE

The unsettled situation in the construction industry today presents a problem of substantial magnitude to the municipalities that have made preparations to provide needed public works. Chaotic labor conditions and shortages of fundamental building materials have resulted in bidding levels far beyond most estimates, giving rise to uncertainty and doubt as to further procedure on the part of municipal officials and their consultants. It must be noted, however, that our national economy is undergoing a major transformation and that all business and industry must make radical adjustments before stability is restored. With the recognition and acceptance of these changes, it is believed that public works construction will take its proper niche and will proceed at an orderly but accelerating pace.

Quick to recognize the trends, the Committee on Water and Sewage Works Development—of "Blueprint Now" fame—acted on January 15, 1946, to recommend "That the Committee . . . be inactivated, but its organization be maintained against such time when it may appear again advisable to resume promotion of needed water and sewage works construction through nationally coordinated effort." This agency led the way to the positive planning of about two billion dollars of sewage and water works construction in the period 1943–45; work "on the boards" by consulting engineers in mid-1945 was thrice the normal volume.

Postwar planning such as was exemplified by the *Blueprint Now* program was an economic insurance policy and, like good insurance, it will pay continuing dividends and return benefits when they are needed most—now or later. Its primary purpose was to provide a backlog of *useful* public works to fill the gap anticipated to be created in the period of industrial reconversion from war to peace. Two developments since the termination of the combat phase of the war were not anticipated, at least to the degree that they are now evident: first, the unprecedented shortage of domestic housing and, second, the revolutionary upheaval in the labor situation. The former item has properly taken its place at the top of the list for attention by the construction industry and the latter, by its abruptness, has dislocated financial planning to an extent that cannot soon be rectified.

Despite this interference, the public works planning initiated during the *Blueprint Now* campaign will be invaluable in speeding the provision of water and sanitation facilities to serve new housing projects and residential areas, in effecting wartime deferred replacement and maintenance in existing works, and in expediting the construction of some new sewage works of demonstrated immediate need. General pollution abatement programs of state agencies, however, will probably lose momentum until construction demands approach a reasonable level and some of this planning may have to be laid aside for reference when the boom has dissipated.

A factor of considerable concern is the frantic quest for construction materials in the face of inventory deficits and limited production capacity. Estimates of construction volume in 1946 range from 8 to 12 billion dollars, of which 5 to 7 billions would represent the cost of materials. Practically everything used in construction is in short

supply, with production committed to back orders for months to come. One manufacturer of electric motors is producing 5-h.p. units on delivery schedule of 54 weeks, clay pipe manufacturers are 6 to 8 months behind in deliveries—the story is much the same for all of the $615,000,000 of materials estimated to be needed for water and sewage works building in 1946. The *Journal of Commerce* reports that building supplies are not expected to balance demands until 1948.

Lester S. Kellogg of the U. S. Dept. of Labor, writing for *Architectural Record*, concludes that prices of building materials are not out of line with present prices of other goods. He points out that wholesale prices of building materials as a group have advanced about 32 per cent and that the major part of the increase was in the price of lumber. Anticipated decline in the price of lumber is expected to be offset by some rise in other prices so that a slight overall increase may take place in the next year.

It is the uncertainty of labor costs that is primarily responsible for the heavy contingency allowances which are boosting present bids by contractors. More reasonable bidding should result when the wage pattern stabilizes, even though this takes place at a higher plane. Concerning construction costs in general, L. R. Howson (1) has this to say:

> "Engineers should be realistic. Postwar construction costs are bound to be materially higher than prewar. In most lines of general construction the increase above 1940 will probably approximate 50% by 1950, and in certain classes of construction such as pipe lines and sewers involving a large proportion of common labor, the increase will be materially higher."

There can be assurance that the immediate volume of sewage works building will compare favorably with prewar levels, even though housing predominates the present pattern of construction. Mention of sanitation needs is noted in discussions of the construction picture by several authorities. A resolution adopted by the Associated General Contractors of America aptly expresses this thought in the statement: "all types of construction are vital to the proper functioning of the nation's economic, education, health and social life and the blanket deferment of all industrial, commercial, hospital, school, sewage, water supply, highway and street, railroad, flood control and other types can seriously obstruct and delay the future development of the nation." Likewise, the *Washington Legislative Bulletin* reports that the Interdepartmental Committee on Construction, comprising certain federal departments and agencies, has given "the green light to highway and reclamation projects, river and harbor improvements, flood control and certain community facilities, such as streets, sewers and waterworks essential to housing." In the estimate of 9 billion dollars of 1946 construction as made by the U. S. Dept. of Commerce, there is included an item of 1.8 billion dollars for non-residential public works, a substantial part of which will be in the form of sewage collection and treatment facilities.

Government controls over construction are also of considerable concern. The Associated General Contractors of America, in their first postwar convention, deplored dilatory enforcement by federal agencies of continued wartime controls over construction materials and wages and went on record "as being opposed to government control over the construction industry by the continuance of wartime regulations beyond the periods currently established by law."

An interesting development is the bill introduced into Congress by Senator Murray "to aid in the stabilization of construction by advance planning of public works, and to reduce, by timing of public construction and by

other means, the violence of seasonal and long-term fluctuations in the total volume of new construction, maintenance and repair work in the U. S." A Construction Policy Board headed by the Secretary of Commerce would carry out the functions of this bill. Properly administered, federal guidance and coordination (not control or regulation) of public works construction would probably be of benefit; certainly there is merit to the aims of Senator Murray's bill.

Which brings us back to planning, the basis of any sound building project. Inactivation of the Committee on Water and Sewage Works Development does not imply that municipalities should suspend study of their sanitation needs and preparations to fulfill them, it means simply that *there is no present justification for extraordinary effort to encourage such procedure*. Under present conditions, cities must determine not only what they need in the way of public works but, in addition, a proper schedule of building that will conform to the limitations of the overburdened construction industry.

After all, the complete slogan of the Water and Sewage Works Development Committee is "Blueprint Now for *Tomorrow's* Needs." And that will always be good advice!

W. H. W.

Reference

(1) Howson, L. R., "Future Costs and Their Effects on Engineering Budgets." *Proceedings*, ASCE, **72**, 3, 337 (March, 1946).

Proceedings of Member Associations

KANSAS WATER AND SEWAGE WORKS ASSOCIATION

Sixteenth Annual Meeting

Topeka, Kansas, March 7–8, 1946

The sixteenth and final meeting of the Kansas Water and Sewage Works Association was held in Topeka on March 7-8, 1946. One hundred and five members and guests registered. All technical sessions were well attended and a number of interesting papers were presented, as follows:

"Taste and Odor Control" by Robert Mounsey, Chief Engineer and Chemist, Lawrence Municipal Water Plant.

"Witchita Operating Experiences" by Robert H. Hess, Superintendent of the Wichita Municipal Water Plant.

"Public Relations" by Major Hagar, Water Superintendent, Lawrence.

"Progress in Chlorination" by J. A. Strang, Wallace & Tiernan Company, Kansas City, Mo.

"Legal Problems in the Operation of Municipal Utilities" by Albert B. Martin, General Attorney, League of Kansas Municipalities of Topeka.

"Sewage Works Planning" by Murray A. Wilson, Wilson & Co., Salina.

"Cast Iron Pipe" by Dewey W. Johnson, Assistant Engineer, The Cast Iron Pipe Research Association, Chicago, Illinois.

"Kansas Water Resources" by R. V. Smrha, Senior Engineer, State Board of Agriculture, Topeka.

"War-Time Experiences in Utilities Operation" by R. E. Lawrence, Black & Veatch, Consulting Engineers, Kansas City, Missouri.

A part of the meeting period was devoted to the organization of the new Kansas Section of the American Water Works Association. Harry E. Jordan, Secretary of the association, New York, was present and spoke to those in attendance about some of the difficult problems now facing the water works profession, and on the aims and activities of the association.

Officers of the Kansas Section of the AWWA were elected as follows:

President—Frank E. Willey, Topeka

Vice-President—E. J. Allison, Salina

Secretary-Treasurer—P. D. Haney, Lawrence

Director—F. A. Russell, Lawrence.

The new officers prepared a tentative draft of the by-laws for the new organization and in the near future will distribute copies of the proposed by-laws for the consideration of the members.

W. H. Wisely, Executive Secretary of the Federation of Sewage Works Associations, presented the Kenneth Allen Award to Murray A. Wilson, Consulting Engineer, Salina, and offered suggestions relative to the formation of the Kansas Sewage Works Association which would function as an independent organization but which would meet at the same time as the Kansas Section of the American Water Works Association. The proposed constitution and by-laws for the sewage works organization were presented and passed upon. New officers for the Kansas Sewage Works Association were elected as follows:

President—Murray A. Wilson, Salina

Vice-President—Neal Harr, McPherson

Secretary-Treasurer—P. D. Haney, Lawrence

Director—P. E. Kaler, Topeka

The Kansas Sewage Works Association will be affiliated with the Federa-

tion of Sewage Works Associations and members of the Kansas organization will receive SEWAGE WORKS JOURNAL and other Federation publications. The new association replaces the Sewage Section of the Kansas Water and Sewage Works Association as a unit of the Federation.

PAUL D. HANEY,
Secretary-Treasurer

TEXAS WATER WORKS AND SEWERAGE SHORT SCHOOL AND TEXAS SEWAGE WORKS SECTION

Twenty-Eighth Annual Meeting

College Station, Texas, February 11–13, 1946

The 28th Annual Meeting of the Texas Water Works and Sewerage Short School was held at College Station, Texas, February 11–13, 1946, in co-operation with the State Board of Health, State Board for Vocational Education and Texas A. and M. College. A total of 372 members and guests were registered; a majority were present for the entire short school. Since W. N. Joiner, President of the Short School, was unable to attend, Joe B. Winston, First Vice-President, presided.

The Short School was opened with an address of welcome delivered by Mr. Gibb Gilchrist, President of the Texas A. and M. College. Lt. Col. Reagan, Sanitary Corps, Office of the Surgeon General in Washington, was scheduled to present a paper at the opening session but was unable to attend and this subject was discussed by Major R. E. Wisenbaker of the Sanitary Corps. V. M. Ehlers, State Sanitary Engineer of Texas, delivered a talk on "Present Trends in Water and Sewage Treatment."

On Monday evening L. A. Jackson presented an interesting paper on "The Importance of Professional Standing to the Water Works Superintendent" followed by R. M. Dixon of Dallas, Chairman of the Texas Sewage Section, who presented a supplementary paper relating to sewage works superintendents.

On Tuesday evening at the annual banquet, Dr. George W. Cox, State Health Officer, gave a progress report of accomplishments in the water works and sewage fields during the past year. Special awards were presented to the city of Corpus Christi for having produced the best effluent from the Oso plant; the city of Gonzales for having completed the greatest improvements to the sewage treatment plant; and to the city of Gladewater for having the greatest ratio of sewer connections completed during the year.

Fred J. King, of the Fort Worth Water Department entertained the group with some "black magic." Honorary life memberships were presented to S. C. Clark of San Benito and R. M. Dixon of Dallas. A $100 Victory Bond was given to Professor Sol R. Wright for his untiring efforts in making a success of the Short School for the past several years.

W. S. Mahlie, Texas Director to the Federation of Sewage Works Associations, delivered a short talk on the desirability of increasing the Texas membership in the Federation and the advantages to be gained by the members.

The program for the 1946 Short School was designed in the nature of sewage works operation discussions to aid operators in preparing for examinations for either water works or sewage plant operator's licenses. Wednesday morning and afternoon were set aside by the Licensing Committee for

the examinations in all grades of water and sewage plant operators and much favorable comment was expresed on this type of program.

The annual business meeting was held on Wednesday at the special luncheon session for all the members. Reports were presented by E. J. M. Berg, Chairman of the Committee on Certification of Sewage Plant Operators, and R. M. Dixon, Chairman of the Texas Sewage Section; W. S. Mahlie, Chairman of the Committee on the Sewage Manual, W. F. Hicks, Chairman of the Auditing Committee, and E. W. Sudderth, Chairman of the Nominations Committee. E. S. Smith gave a report on the meter schools that have been scheduled to be conducted under the auspices of the Texas Water and Sanitation Research Foundation. All committee reports were accepted by the membership.

The Texas Sewage Works Section elected the following officers to serve during 1946:

Chairman—L. C. Billings, Dallas
Vice-Chairman—J. H. Sorrels, College Station
Secretary—V. M. Ehlers, Austin
FSWA Director—E. J. M. Berg, San Antonio

A motion was made by R. U. Andrews and passed that the Executive Committee be instructed to consider the advisability of having a four-day Short School next year and that two men of national prominence be invited to deliver addresses or papers at some of the general sessions. At the closing of the meeting Frank Metyko gave a brief resume on Federal anti-pollution legislation now pending in Congress.

Since there was no further business the meeting was adjourned and one of the most successful and best attended Short Schools was concluded.

V. M. Ehlers,
Secretary

NEW YORK STATE SEWAGE WORKS ASSOCIATION

Eighteenth Annual Meeting
New York City, January 18, 1946

The eighteenth Annual Meeting of the New York State Sewage Works Association was held in New York City on January 18, 1946, with headquarters at the Pennsylvania Hotel. This meeting proved to be one of the largest and best meetings ever held by the association with 325 members and guests registered. It was an exceedingly interesting meeting in all its phases, having an excellent technical program, a good luncheon meeting and it was made more enjoyable by seeing so many of our members who have returned from service in the armed forces.

On January 17, members of the association were guests of the Sanitary Engineering Division of the A. S. C. E., which held its meeting at the Hotel Commodore.

The Executive Committee of the New York State Sewage Works Association met on the evening of January 17 in the Pennsylvania Hotel. The meeting was presided over by Dr. George E. Symons, president of the association. Uhl T. Mann, Superintendent of the Ley Creek sewage treatment plant at Syracuse, was elected President for the year 1946. Alexander G. Martin of Kenmore was elected Vice-President. A. S. Bedell of the New York State Department of Health, Albany, was reappointed Secretary-Treasurer, as were J. C. Brigham, also of the Department of Health, Albany, and A. W. Eustance, District Engineer of the Department of Health, Middletown, reappointed Assistant Treasurer and Assis-

tant Secretary, respectively, for the year 1946.

The question of the June meeting of the association was discussed and the President and the Secretary were appointed as a committee to canvass the possibility of having this meeting at Elmira. The second choice was designated as Utica. It was the consensus of the Executive Committee that a June meeting should be held.

The Executive Committee adopted the report of the Kenneth Allen Memorial Award Committee and passed a resolution creating a new award to be known as the Lewis Van Carpenter Memorial Award in honor of the late Professor Lewis Van Carpenter who was not only an outstanding sanitary engineer and teacher, but also always had a keen interest in the welfare of the operator. This award has been established for the best paper submitted by an operator during each calendar year. It was decided that the personnel of the Kenneth Allen Memorial Committee would act as the personnel for the new Lewis Van Carpenter Memorial Award but that in the future this committee be known as the Memorial Awards Committee.

There was considerable discussion concerning the Federation award for operation reports as compared with the New York State Sewage Works Association Rating Award and it was decided to appoint a committee to investigate the bases for making the two awards and to report to the Executive Committee. President Symons appointed the following personnel for this committee: Mr. A. F. Dappert, *Chairman;* Messrs. Donaldson, Fischer, Eustance and Denise. Later, John R. Downes was added since he served on the original committee. It is expected that this committee will report to the next annual meeting of the Executive Committee in January, 1947, with a progress report at the Spring Meeting.

On January 18, the annual meeting was held in the Salle Moderne Room of the Hotel Pennsylvania. President George E. Symons presided. During the business session it was announced that Glenn Searls of Rochester, Edwin C. McKeeman of Freeport and Richard C. Gorman, Jr., of Hornell had been elected to serve a 3-year term on the Executive Committee of the association.

The technical portion of the program, which was more than usually well attended, started with a paper on "Air Flocculation of Sewage" by Uhl T. Mann, Chief Operator of the Ley Creek sewage treatment plant, Syracuse, N. Y. In this very interesting paper, he pointed out that he had been flocculating the sewage with air without the addition of return sludge mainly because his problem was one of disposing of excess sludge. In his paper, he indicated that the results obtained by this method were somewhere between those obtained by a trickling filter and a standard activated sludge plant and that it did result in a considerably less volume of sludge to be handled. Mr. Mann stated that he had found that the reduction of B.O.D. was much more uniform than that obtained with the standard activated sludge method, although the effluent was not as sparkling in appearance.

This paper was discussed by Lloyd R. Setter, Principal Sanitary Chemist, Department of Public Works, New York City. He pointed out that there was only a 13 per cent reduction in the efficiency of this method of operation as compared to activated sludge. He stated that "modified aeration" might be a better term to apply to this method than air flocculation. He compared the results obtained by Mr. Mann with those he had acquired at New York City plants and with the results obtained at several other plants throughout the country and this comparison indicated very satisfactory results for the method discussed by Mr. Mann. There was considerable discussion from the floor of these two interesting papers.

The luncheon meeting was held at noon in the Penn Top Room at the Hotel Pennsylvania. Some delay was experienced because the attendance was much greater than had been anticipated. President Symons presided.

Mr. E. C. LaValley, Chairman of the Rating Committee of the association, presented the Annual Rating Award to Harry Monsell, Superintendent of Sewerage in the village of Greenport. In his remarks, he noted that Mr. Monsell had been a consistent contributor to the rating contest.

This year was the first year in which an award was granted to a previous winner, under the rules of a new contest set up by the association in 1945. The winner of the certificate for the presentation of the best rating report from a previous winner was Edward J. Smith, Superintendent of the Niagara Falls sewage treatment plant.

Charles R. Velzy, Chairman of the Kenneth Allen Memorial Award Committee, presented to Channel Samson the Lewis Van Carpenter Award for the best operator's paper presented during the year 1945. It was noted that this is a new award, in the form of a certificate, just established by the Executive Committee to be issued annually to operators for the best operation paper during the year.

Dr. Symons presented Vice-Admiral J. K. Hoskins, President of the Federation of Sewage Works Associations. After a few general remarks on the activities of the Federation, Admiral Hoskins introduced W. H. Wisely, Executive Secretary-Editor, who spoke on the current activities of the Federation and pointed out the need of a drive for new members. At the conclusion of his remarks he presented to Dr. Lloyd R. Setter the Harrison Prescott Eddy Award which is given by the Federation for the outstanding paper during the year on research in sewage treatment.

A very interesting address accompanied by moving pictures on "Cooperative Sanitation in the Americas" was given by Colonel Harold B. Gotaas, President, Institute of Inter-American Affairs, Washington, D. C. His discussion, and particularly the moving pictures, were most informative and interesting.

The afternoon session was opened by Anthony J. Fischer, Development Department, The Dorr Company, New York City, who gave an illustrated discussion on "Impressions of Postwar Germany." In this discussion and from the slides, it was interesting to note the very considerable damage to many German cities visited. Dr. Fischer, in showing a picture of Dr. Karl Imhoff, stated that the latter was not planning to do much in the field of sewage treatment for some years to come because he said there will be no sewage treatment until other more important works had been completed in the restoration of Germany.

The second paper of the afternoon was entitled "Solids Removal as Influenced by Sewage Treatment Plant Design" and was given by Thomas Riddick, Consulting Engineer, of New York City. In his paper he pointed out some of the present fallacies of rating a sewage treatment plant and provided detailed directions for such rating. The last paper of the afternoon on "Grit Collection and Conditioning" was given by Mr. R. C. Merz, Sanitary Engineer, Chain Belt Company, Milwaukee, Wisconsin. This was a very interesting paper on the factors influencing the design of grit collecting systems and included a number of lantern slides.

Time did not permit the last scheduled discussion on "Thumbnail Sketches of War Zone Sanitation" and it is felt that a very enjoyable feature of the program was lost because of this fact.

A. W. EUSTANCE,
Assistant Secretary

ARIZONA SEWAGE AND WATER WORKS ASSOCIATION

Annual Meeting

Phoenix, Arizona, December 1, 1945

The Arizona Sewage and Water Works Association held its first conference since 1942 at the Hotel Adams, Phoenix, on December 1, 1945. This was a one-day meeting devoted entirely to association business and technical papers. For this short post war meeting entertainment and honored guests were dispensed with.

Among the Californians who are members of the Arizona association and contributed to the meeting were A. M. Rawn, Chief Engineer and Manager, Los Angeles County Sanitary District (a life member of the association), Ray Goudey, Sanitary Engineer, Los Angeles Water Department (also a life member), and Byrl Phelps, Sanitary Engineer, San Diego, Docks and Harbors.

John Prendergast of Ajo presented an outstanding paper on "Problems of a Small Sewage Disposal Plant." Other contributors to the technical program were John A. Carollo (just returned from the Army Sanitary Corps) of Headman, Ferguson and Carollo; Harold Schwallen, Irrigation Engineer, University of Arizona; Dick Bennett, City Engineer of Phoenix, and Geo. W. Marx, Director of the Division of Sanitary Engineering, Arizona State Department of Health.

Among the highlights of the conference were the presentations of awards to two Arizona men by the Federation of Sewage Works Associations, an international association composed of member associations in the United States, England, Canada and South America. The Arizona Association is a member. A. M. Rawn, a past president of the Federation, was the official representative to make the presentations.

The Kenneth Allen Award was presented to Dario Travaini, superintendent of the Phoenix sewage disposal plant. This award may be given to a member of a member association once in three years. The Arizona Sewage and Water Works Association selected Dario Travaini to receive the award because of his activities in the field of sewage disposal and his interest in the welfare and objectives of the association. Mr. Travaini served as the first president of the Arizona association and is the first Arizonan to receive the Kenneth Allen Award.

The Federation, through Past President A. M. Rawn, presented George W. Marx, Director of the Sanitary Engineering Division of the Arizona State Department of Health, with a $100-war bond for increasing the Federation membership of the Arizona Association 140 per cent, thereby winning over all the other Member Associations.

The membership (approximately 150) of the Arizona Sewage and Water Association consists of sanitary and civil engineers interested in sewage disposal and water works, sewage and water plant operators, health department sanitarians, representatives of equipment manufacturers, sewage and water plant officials and individuals interested in problems of sewage disposal and water works and water plant operation.

The 1945-46 officers of the association are: *President*—E. S. Borgquist, Head Professor of Civil Engineering, University of Arizona; *First Vice-President*—Harold Yost, of Yost and Gardiner, Consulting Engineers; *Second Vice-President*—A. W. Miller, manager, Johns Manville; *Secretary-Treasurer*—Geo. W. Marx, Director, Division of Sanitary Engineering, Arizona State Department of Health. Executive Board members are: A. L. Frick, District Manager, Wallace & Tiernan,

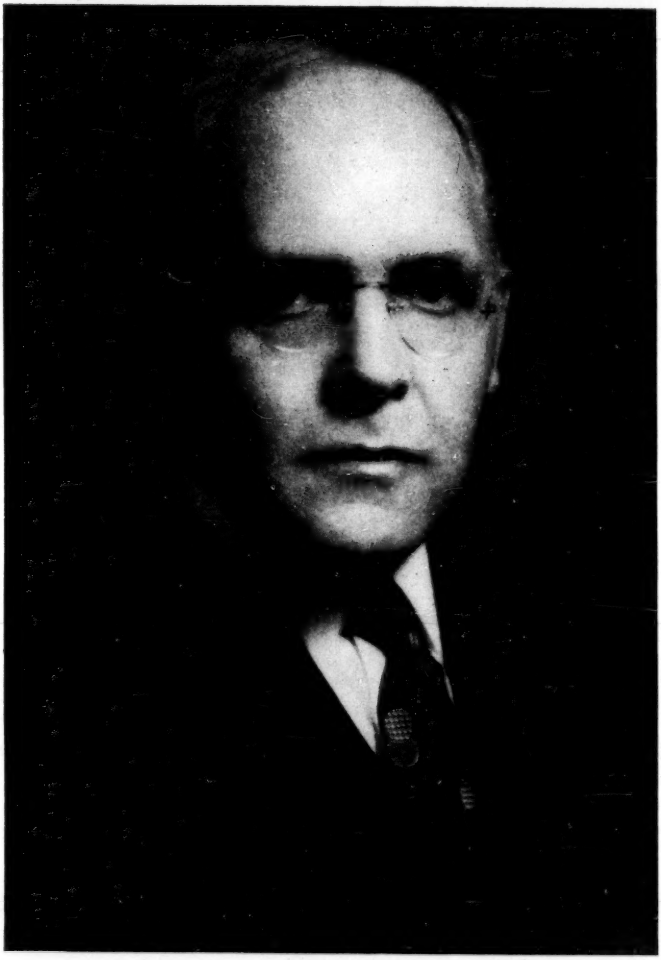
Los Angeles; Dario Travaini, Superintendent, Phoenix sewage disposal plant; H. H. Idle, Secretary, Arizona Edison Company; Guy Rhoads, City Engineer of Safford, Arizona; Merrill Biggs, Water Superintendent, city of Tucson; Bob Cushing, Sanitary Engineer, Headman, Ferguson and Carollo, Consulting Engineers.

The Arizona association planned an annual spring meeting held at Tucson during the month of April, 1946. This was a two-day meeting and negotiations were then underway to have a two- or three-day school at the University of Arizona for sewage and water plant operators just before, or after, the annual conference.

GEORGE W. MARX, *Secretary*

MEMBER ASSOCIATION MEETINGS

Maryland-Delaware Water & Sewage Works Assn.	Lord Baltimare Hotel, Baltimore, Md.	May 16–18
New England Sewage Works Assn.	Hotel Pickwick Arms, Greenwich, Conn.	May 17
Pacific Northwest Sewage Works Assn.	Gearhart Hotel, Gearhart, Ore.	May 22
New York State Sewage Works Assn.	Hotel Hamilton, Utica, N. Y.	May 24–25
Florida Sewage Works Assn.	Gainesville, Fla.	June 5–8
California Sewage Works Assn.	Monterey, Calif.	June 9–11
Central States Sewage Works Assn.	Purdue University, Lafayette, Ind.	June 13–14
Ohio Conference on Sewage Treatment	Hotel Mayflower, Akron, Ohio	June 20–21
Pennsylvania Sewage Works Assn.	State College, Pa.	August
South Dakota Water and Sewage Works Conference	Deadwood, South Dakota	Sept. 20–21
North Dakota Water and Sewage Works Conference	Mandan, North Dakota	September
Iowa Sewage Works Assn.	Iowa State College, Ames, Iowa	September
Federation of Sewage Works Associations	**Royal York Hotel, Toronto, Canada**	**October 7–9**



Arthur S. Bedell

Federation Affairs

ARTHUR S. BEDELL (1887–1946)

In Memoriam

Arthur S. Bedell was born on January 29, 1887, in Brooklyn, N. Y. His death came suddenly at his home in Delmar, N. Y., on March 30, 1946.

Upon his graduation from Dartmouth College in 1909, where he received the degree of A.B., Mr. Bedell became Registrar and Instructor in Science and Engineering at Robert College, Istanbul, Turkey, which positions he filled until 1916. In 1917, he returned to the United States for employment as Assistant Bacteriologist in the Division of Laboratories and Research of the New York State Department of Health, leaving the department to serve as sanitary expert for the American Red Cross Commission to Greece during 1918–19.

Mr. Bedell accepted an appointment as Assistant Professor of Civil Engineering at Robert College in 1919, receiving the degree of B. S. in Civil Engineering from that institution in 1921. He then served for a short time in 1922 with the International Health Board of the Rockefeller Foundation, after which he became Chief Sanitary Engineer in the Utah State Board of Health. He resigned this position in 1925 to accept appointment as Sanitary Engineer in the Division of Sanitation of the New York State Department of Health. Mr. Bedell became Chief of the Bureau of Sewage and Waste Disposal of that division in 1937, which position he held at the time of his death.

Arthur Bedell was an indefatigable worker in the New York State Sewage Works Association and in this Federation. He was a charter member of the NYSSWA, serving faithfully as Secretary-Treasurer of that organization from the time of its creation in 1929 until his death.

He served as Vice-President of the Federation in 1940–41 and became the second President in 1941–42, at a time when his duties were most demanding because of the extensive reorganization of the Federation at that time. His calm and considerate attitude, his penchant for perfection in every detail and his unselfish devotion of energy and interest to the affairs of the Federation in this critical period gained the respect and esteem of all of his associates. The writer particularly acknowledges Mr. Bedell's thoughtfulness, judgment and guidance and counts him among those men who have contributed most to the Federation's development and growth.

At his passing, Mr. Bedell was Chairman of the Committee on Honorary Membership and was a member of the General Policy Committee. In these functions and in others he was always ready to accept more than his share of responsibility.

He also held membership in the American Public Health Association and in Phi Beta Kappa, national honor society.

Mr. Bedell is survived by his wife, Elsie Bedell, and two daughters, Mrs. Stanley Hummel and Mrs. James McGraw.

W. H. WISELY

CANADA BECKONS IN OCTOBER!

Arrangements for the Nineteenth Annual Meeting of the Federation, to be held in Toronto, Canada, on October 7-9, 1946, are well under way, according to Dr. A. E. Berry, Chairman of the Convention Management Committee, and immediate Past-President of the Federation. Owing to the omission of the regular annual meeting of the Federation membership-at-large in 1945, a record breaking attendance is expected at the Toronto convention.

Host to the Federation at this meeting

will be the very much alive Canadian Institute on Sewage and Sanitation, now the fourth largest unit of the Federation. Although the convention headquarters and exhibits will be set up in the Hotel Royal York, the Canadians are unselfishly planning to utilize accommodations at the King Edward Hotel so as to conserve hotel quarters at the Royal York for those attending from the States.

Selection of Monday, Oct. 7, through Wednesday, Oct. 9, as the meeting dates, instead of later in the week as in the past, is another move to facilitate the housing of registrants. This decision was reached after due consideration of Canadian experience in the most successful handling of large conventions.

The technical program is taking shape under the leadership of F. W. Gilcreas, Chairman of the Publications Committee. Plans are under way for papers on the following topics: Experiences with Activated Sludge Treatment at Toronto; Control of Scum in Digesters; Dual Disposal of Garbage and Sludge; Incineration Problems; Direct Heating of Sludge—a new development; and Sewage Works Financing. Other papers will feature industrial waste treatment and stream sanitation problems. The "Operators' Breakfast Forum," a popular program feature in the past, will be conducted under the leadership of the Canadian Institute on Wednesday morning.

The Federation's Board of Control will hold its customary pre-convention business meeting on Sunday, Oct. 6, after which members of the Board will be guests of the Canadian Institute at a dinner the same evening. The regular post-convention business session of the Board will be held on Wednesday afternoon, after close of the technical sessions.

Indications point to the fact that the exhibits to be staged by the Water and Sewage Works Manufacturers' Association will be the largest and most interesting yet presented at any meeting of the Federation. All details of the exhibits are being supervised by Arthur T. Clark, Secretary-Manager of the manufacturers' association.

Those who are planning to attend the Nineteenth Annual Meeting of the Federation (and likewise all hopefuls) are urged to make reservations either at the Royal York or the King Edward Hotel without delay. All rooms at the Royal York are equipped with twin beds. To conserve accommodations, arrange with a friend to share a room and make reservations accordingly. Reservations can always be cancelled later should it be found that plans to attend must be abandoned for any reason.

Many of you who will read this have not had a genuine vacation for some time. If you have never seen Canada in its autumnal splendor of October, here is a real opportunity—a postwar vacation in Canada, where folks are friendly and your dollar goes further.

L. H. Enslow, *Chairman*
Committee on Publicity and Attendance.

SURPLUS PROPERTY PURCHASE PROCEDURE

Early in April, Federation headquarters distributed mimeographed "Instructions for Public Health Claimants," as issued by the Office of Surplus Property Utilization of the U.S.P.H.S. The material was sent as a special service to all Active, Corporate and Associate members of the Federation residing in the United States. Any member who did not receive a copy, or who desires additional copies, will be supplied on request.

Municipal sewage works departments are included in the group of "public health claimants" who are eligible to purchase surplus war property at a discount of 40 per cent from their fair value. Potential purchasers should request notification of sales offerings from the War Assets Corporation office in their district (see page 4 of instructions), mentioning that they are interested in possible purchases as a public health claimant. A representative of the U. S. Public Health Service has been stationed in each of these offices to expedite handling of inquiries and applications for purchase.

Reviews and Abstracts*

Conducted by

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Fuel Fertilizer and Calcutta Sewage Sludge. By P. C. BOSE. *Journal of the Association of Engineers* (Calcutta), 21, 7–16 (March and June, 1945).

This paper contains a discussion of the problem of sludge disposal, and the utilization of sludge and gas derived from digestion.

The growth of the city of Calcutta has been phenomenal, having increased from a population of 1,200,000 in 1931 to 2,100,000 in 1941, according to census figures for those years. The population is now believed to be about 3,600,000, including members of the allied forces stationed in the city.

The conventional methods of sludge disposal are discussed, and the possibility of composting with municipal refuse after removal of glass, metals and the like, is mentioned. Studies would be required before the feasibility of disposal of sludge by composting could be determined.

Digestion of sludge and utilization of gas and dried sludge is suggested as the best solution of the problem for Calcutta. Use of dried sludge as a fertilizer is urged. Possibilities in the utilization of gas is discussed at some length. The discussion is based on the utilization of gas as fuel for motor vehicles.

A conservative yield from sedimentation tank sludges is 0.5 cu. ft. of gas per cap. per day for a population of 3.6 millions; 1.8 mil. cu. ft. of gas per day would be expected. Analysis of sludge gas from Dadar, Bombay, is given as follows:

Methane	65–70%
Carbon dioxide	27–31%
Oxygen	0.2–0.4%
Nitrogen	2–5%
Hydrogen sulfide	0.04–0.1%
B.T.U.	650–750

To remove carbon dioxide the gas must be washed. 140 cu. ft. of washed sludge is equivalent to 1 gal. of gasoline and from Calcutta's sludge an equivalent of 9,000 g.p.d. could be obtained. Calcutta would have an excess of 8,000 g.p.d. which could be sold after taking care of her own needs for the municipality.

Analyses of digested sludges at various cities in India are presented, as follows:

City	Type of Sludge	Per Cent		
		Total Nitrogen	P_2O_5	Organic Matter
Delhi	Activated and dried	2.9 to 4	1.5 to 2.4	40 to 50
Bombay	Activated, digested and dried	2.5	1	
Calcutta (1944)	Primary digested and dried	2.9 to 3.5	1.5 to 2.5	40 to 50
Patna (1939)	Activated, digested and dried	3.5	2.3	70

T. L. HERRICK

* It will be appreciated if Miss Swope is furnished all periodicals, bulletins, special reports, etc., which might be suitable for abstracting in THIS JOURNAL. Publications of public health departments, stream pollution control agencies, research organizations and educational institutions are particularly desired.

Sewerage and Sewage Disposal in Retrospect and Prospect. By M. Lovett. *The Surveyor,* **104**, 587–591 and 607–610 (Oct. 5 and 12, 1945).

The most notable impression which may be obtained from a study of the history of sewerage and sewage disposal is the extent to which progress has lagged behind immediate needs. The reason for this is the belief that sanitation brings no financial reward.

Present conditions are vastly improved over the conditions of a century ago, at which time the objective was to attain a certain minimum standard of safety at the smallest possible cost. Even at present the austerity pattern of sewerage and sewage works design persists. This is due to a lack of information by the general public as to the importance of sewage disposal. The author states that in this connection an American official recently showed that the annual outlay of the average American family on toilet paper greatly exceeded its contribution to the sewage rate. In his view, the author feels that it is the duty of sanitarians to educate the general public that sewage disposal and rivers' pollution prevention are essential for national welfare and not merely something forced upon them at considerable expense by a bureaucratic supervising authority.

The origin of modern sewerage systems may be traced to early road making history. Improvements in road surfacing increased the rates of runoff in wet weather. This runoff had to be controlled by carrying in roadside drains to the point of disposal. These were the first sewers.

Congested conditions associated with rapid industrial growth in towns made the disposal of part or all liquid wastes into rivers or streams expedient. When the capacity of the sewers became inadequate, larger ones or duplicates were generally constructed to provide a relief sewer or to divert part or all of the surface water discharges to a separate sewer. Accordingly, drainage areas were developed on what we now know as the combined, the partially separate, and the separate systems. The advantages and disadvantages of the three systems are still debated.

The author quotes an opinion from the fifth report of the Royal Commission on Sewage Disposal as follows: "The cases in which the provision of a separate system can properly be justified are rare. It seems generally to be assumed by advocates of the separate system that the liquid brought down by surface water sewers is sufficiently pure to need no further purification and that further by excluding this water from the ordinary sewers a much smaller plant will suffice for the purification of the sewage. Neither of these assumptions is altogether justfied." An opposite view is then quoted as follows: "I have always considered that the mixture of sewage with rainfall which now indiscriminately prevails is wholly due to the same want of forethought which failed to anticipate the effect of turning our rivers into sewers."

Some of the arguments used in favor of combined systems are unsound. One argument is the supposed "tonic" effect of storm water on sewage purification works which in fact points to faulty design or inadequacy of the purification plant. Another is the alleged value of storm flows for scouring foul sewers, which confuses the issue by ignoring the fact that in sewers where such beneficial scouring occurs there is a more significant trouble that over far greater and more potentially dangerous periods they will be in a stagnant condition.

One of the worst examples in principle is that of providing a device at the inlet to the sewage works for by-passing all flows in excess of six times the dry weather flow. Having provided sewers large enough to convey such flows to the works, it is surely not unreasonable to provide adequate tank treatment. The author cites an opinion of J. H. Edmondson to the anomolay of assessing the volume of storm water to be treated at six times the dry weather flow when in fact the volume of storm water bears no relation whatever thereto. For example, if the dry weather flows were respectively 15 and 40 gal. per capita per day, the maximum flows to be treated would be 90 and 240 gal. per capita per day. This led him to suggest that a population basis would be more satisfactory.

The equalizing effect of large sewerage systems upon sewage flows at West Middlesex is cited. The maximum rate of flow received at the treatment works was 180 gal. per capita, although flows from individual districts may have been as high as 300 gal. per capita. The author feels that there should be an increasd capacity

for storm water treatment at sewage works; that storm water tanks should be designed so that the first and usually most polluting flush of storm water does not reach the stream. Where new sewerage systems are to be constructed, the most satisfactory procedure would be to provide separate storm drains with perhaps a leaping weir connection into the sanitary sewer. The first flush of storm water would then pass to the treatment works where the entire flow would be given full treatment. Subsequent flows in the storm sewer would then flow to the nearest water course. This method he feels would be logical as it would function for each impervious area under consideration and be independent of either population or dry weather flow.

The design of sewage disposal works in Britain has followed largely recommendations formulated by the Ministry of Health. The recommendations should be considered as directives and not requirements. Developments such as continuous flow recorders, improved screening arrangements, grit removal devices, and settling tanks are discussed, the latter believed to yield more return per unit of cost than any other stage of treatment. In regard to settling tank design the advantage of frequent or continuous removal of sludge and the use of sedimentation tanks for balancing inequalities in rates of flow is cited.

In biological treatment processes the bacteria must be regarded as living beings, to be well housed, well brought up, and well nourished; to be carefully and regularly fed; and to be kept from getting into bad ways during their normal life span which in the case of bacteria is probably only three to five minutes.

Correctly designed percolating filters treating settled sewages at normal dry weather rates of between 50 and 120 gal. per cu. yd. per day when followed by tank treatment for humus removal give a final effluent which leaves little to be desired. High rate filters are useful for partial treatment processes. Their ultimate value will depend upon the ease and economy with which such secondary treatment as is required can be achieved. The promising results obtained seem to depend largely on recognition of the importance of uniform distribution and good ventilation. Experiments with enclosed aerated filters indicate production of a well nitrified effluent at about three times the normal rate for standard filters. Double filtration appears to be promising.

Recirculation, which in its simplest form consists of diluting incoming sewage with several times its volume of filter effluent is best regarded as a partial treatment process unless the sewage is very weak. The principle was used by Dr. G. J. Fowler in 1910 in the treatment of spent ammoniacal liquor from a gas works.

There is an essential similarity in basic principles between aeration processes and biological filtration. Active sludge flocs are fragile. Some attempts have been made to fortify the sludge by addition of inert substances such as soil, marl, flue dust, iron or aluminum hydroxide, sawdust, finely divided asbestos and even sponge-rubber blocks. Such attempts are still experimental. A difficulty of the aeration process seems to be the obtaining of a sufficiently intimate admixture of oxygen and of arranging conditions to suit widely different types of organisms. Where the sewage is weak and there are no deleterious trade wastes, these conditions are easily met but split stage operation with segregation of the various types of organism may be desirable in other circumstances.

The development of mechanical and other surface aeration systems as substitutes for diffused air aeration systems is mentioned. Truly comparable data regarding the various aeration systems are difficult to obtain.

With regard to sludge disposal, the development of separate sludge digestion tanks is traced at Birmingham in 1910 and also improvements in design to date. Early attempts to dewater sludge in filter presses and comparison with present day vacuum filters operating on elutriated sludge is discussed.

In conclusion, occupational hazards at sewage treatment works and the beautification of sewage treatment works are discussed. Attention should be given to both.

K. V. Hill.

Controlled Septicity of Sewage. By W. Watson. *The Institute of Sewage Purification* * (November 10, 1945).

The first section of this paper is devoted to a discussion of the present conception of the septic action in the treat-

* Preprint of the paper as presented on November 10, 1945, in Wakefield.

ment of sewage. The advantage of the septic tank over the plain sedimentation tank lies in the reduction in sludge volume which takes place by septic action in the sludge layer.

However, the septic action described in this paper is extended to the liquid layer to bring about clarification of the effluent. Advantage is taken of the fact that sewage left to stand for several days in tightly stoppered vessels will clarify even though it may take on some color. A description and drawing of the apparatus is given and is similar to "pocket" activated sludge plants where the settling tank forms the circumference of the reaction chamber with the sludge returning directly to the reaction chamber. However, the agitation in the reaction chamber is gentle and the top is closed over. Sludge is allowed to accumulate until it reaches 19 per cent by volume on settling for 1 hr. and then removed at intervals to maintain that ratio. Settled sewage was used to feed the tank at hourly intervals and composites of the feed and effluent were analyzed daily. Once the tank had gained equilibrium no difference was found between 54 and 18 hours detention. Each detention period showed between 40 and 50 per cent purification over the influent, depending upon the method of analysis. The experiment was not continued to find the shortest detention period which would serve to maintain this degree of purification.

The effluent from this tank was run through an experimental trickling filter and compared with a similar filter receiving the settled sewage. Sixty per cent more septic liquor gave a slightly better filter effluent in most cases and a much better effluent as far as the suspended solids were concerned. However, in actual practice a filter would have to be covered to take care of the odors from septic tank effluent.

These results indicate that a "bioseptic sludge" is capable of bringing about a removal of oxidizable organic material in sewage. The sludge settled well, perhaps because it failed to develop a methane fermentation.

In concluding his paper the author states, "The experiments are also far from complete in the fact that no investigation on the sludge was made with regard to its organic and mineral ratio, its drying properties, its digestibility, etc.

"The process might also be a rapid means of coagulating and partially purifying certain non-toxic but difficult trade wastes such as wool scouring and textile waste, brewery and tannery waste, etc."

ROBERT S. INGOLS

The Work of the Water Pollution Research Laboratory during the War. BY B. A. SOUTHGATE. *The Institute of Sewage Purification** (December, 1945). 11 pages.

The Water Pollution Research Board was formed in 1927 for the purpose of making investigations in the field of water polution prevention and relevant matters affecting the purity of water supplies. Just before the war arrangements had been made to build a central Water Pollution Research Laboratory but with the start of the war this project was dropped. It was realized, however, that during the war many problems would arise in the treatment of water, sewage and trade effluents and a temporary laboratory was made ready for service in 1940. Since 1939 the staff has increased from 12 to 49.

Prior to the war, work had been done on the treatment of sewage and trade wastes and on the effects of stream pollution on fish life and bottom deposits. Since 1930 the Laboratory has been responsible for the preparation of a "Summary of Current Literature" covering the fields of water treatment and water pollution.

Of the work in progress before the war, the studies on biological filtration were the only ones continued after 1939. These studies involved experiments with alternating double filtration and the treatment of settled sewage with recirculation of an equal volume of settled filter effluent. A paper giving the results of three years work on the latter project is being prepared. An investigation of filter fly control revealed that D.D.T., when applied under controlled conditions, kills the fly larvae without substantially affecting the other useful organisms present in the filter.

The Laboratory studied the viability of certain pathogenic bacteria during the drying and digestion of sludge. There remains, however, much further work to be

* Preprint of paper presented at Birmingham, December 11, 1945.

done before risk or lack of risk arising from the use of sludge as fertilizer can be properly assessed.

An investigation has been started on the chlorination of sewage from the City of Coventry.

The major part of the work of the Laboratory during the war has been on the treatment and disposal of industrial wastes.

Study of wastes from a flax plant indicated that from the retting of 1 ton of flax straw the volume of waste waters would be about 7,000 gal. and that the B.O.D. of the liquid would be 1,600 to 2,000 p.p.m. The retting process is anaerobic and the retting liquid is acidic and foul smelling due to the presence of organic acids. Chemical treatment is unsatisfactory. Treatment by percolating filters is difficult. It was found, however, that the retting tank liquor could be reused if aerated during the retting process. Under these conditions decomposition of the organic matter in the retting liquor occurred under aerobic conditions. The B.O.D. after four aerobic rets was 2,040 p.p.m. and increased to only 4,600 p.p.m. after 31 rets. With this process there is normally no discharge of polluting liquor except at the end of the retting season when the liquor in the system is spread over a large area of ground and is thus disposed of without nuisance.

Serious stream pollution and interference with sewage treatment processes are caused by waste waters from the pickling of copper in sulfuric acid. The two main wastes are (1) spent pickle liquor containing sulfuric acid and copper sulfate and (2) wash water containing small concentrations of these substances. Copper and acid may be recovered electrolytically from the pickle liquor but it is not economical to treat the wash water in this manner. One method of handling these wastes which proved satisfactory was their treatment with metallic iron whereby the iron replaces the copper in the solution. A full scale recovery plant based on this principle was constructed and the copper concentration in the waste washing waters was reduced from 2,000 to 50 p.p.m. Sludge after air drying contained 43 per cent copper. The treated wastes containing soluble iron salts could be discharged to sewers or further treated with lime for iron removal.

Wastes from shell-filling factories, containing trinitrotoluene, ammonium nitrate, etc., were successfully handled by existing sewage treatment plants as long as care was exercised in controlling the rate of discharge and an effort made to minimize the amount of material discharged in the waste waters. Occasionally excessive amounts of ammonium nitrate caused rising of sludge in sedimentation tanks.

Wastes from vegetable dehydration plants were studied and an investigation was made on the treatment of such wastes by sedimentation and biological filtration.

Studies were continued on the treatment and disposal of waste waters from beet sugar factories. It is believed that by adopting the principle of re-use of liquors as much as possible and by making certain modifications in technique it should be possible to reduce to a relatively small volume the waste waters discharged.

Wastes from the caustic soda treatment of straw, a process used to increase its food value, were investigated. In this process about 200 lbs. of straw are soaked in 200 gal. of 1.5 per cent caustic soda solution and then washed with about 600 gal. of water. Samples of the wash water had a B.O.D. of 800 p.p.m. and were alkaline in reaction. No practicable treatment method could be found which would be suitable on a large number of scattered farms. Practicable disposal methods were percolation into the ground or discharge to surface water where there was adequate dilution.

The most promising line of attack on paper manufacturing wastes appears to be in the direction of developing more efficient methods of washing the pulp so that a greater proportion of the soda used for digestion can be recovered. At present the wastes discharged from many mills is too alkaline for satisfactory treatment by biological methods.

Work is still proceeding on methods of handling wastes from the manufacture of the new insecticide, D.D.T.

Strong wastes from the manufacture of synthetic resins can be handled by evaporation. The more dilute wastes can be treated by means of percolating filters. It was found that such filters worked satisfactorily even though the waste applied contained as much as 240 and 120 p.p.m. of formaldehyde and cresylic acid, respectively.

A report on the treatment of chromate wastes by barium carbonate for the precipitation of barium chromate and treatment by reduction with metallic iron or ferrous sulfate and subsequent precipitation as chromium hydroxide is being prepared.

One type of oil waste derived from machine shops was successfully treated by coagulation with alum at controlled pH.

Treatment of wastes from electro-plating industries is a problem of considerable difficulty due to the great variety of wastes. Treatment methods for cyanide bearing wastes involving the use of ferrous sulfate and alkali which will reduce the cyanide concentration to about 20 p.p.m. have been developed. However, it is difficult to reduce the concentration below this value. Another method is to treat the liquid with chlorine and an investigation of this process is under way.

A paper summarizing the chief results of the effects of various treated wastes on fish life will be published shortly.

The war caused great changes in the industry of the country and there were instances of serious pollution of surface waters. In general however, careful consideration was given to the avoidance of pollution particularly from industrial effluents. The war was responsible for the intensification of work on methods of treatment of industrial wastes.

Twenty references.

PAUL D. HANEY

Computing Coagulant Requirements in Sludge Conditioning. By A. L. GENTER *Proc. Am. Soc. Civ. Eng.*, **71**, 307–30 (1945).

The object of this paper is to present some evidence of a mathematical relationship between the quantities of chemical coagulants required by various sludges and certain basic sludge assays. A relationship of this kind should supply an explanation of where chemical coagulants go in dosing a typical sludge, and it should enable a designing engineer to select the most economical method of sludge processing for given conditions. The studies relate principally to ferric chloride, as that compound is the most effective coagulant. Other chemicals considered include lime, chlorinated copperas, and ferric and aluminum sulfate.

Studies have shown that the water portion of sludge has a distinct chemical demand apart from that of the solids to be coagulated. The bicarbonate alkalinity is a measure of that demand. It may be shown that the percentage $FeCl_3$ requirements for the liquid portion is 1.08 times the alkalinity expressed as a percentage of the solids.

In order to arrive at a basis for estimating the ferric chloride demand of the solids portion, data were collected from plants where complete statistical averages were available and where careful filter operation is practiced. Types of sludges represented were, primary thickened, digested and elutriated (4 plants), digested activated, digested and elutriated activated, and thickened activated. In using these data the ferric chloride demand for the water portion was computed on the basis of the alkalinity expressed as a percentage of the sludge solids. This was deducted from the total actual dosage to obtain the requirements of the solids portion. These values plotted against the corresponding percentages of volatile matter formed a smooth curve. This was converted to a straight line equation and the constants determined, resulting in the following empirical equation,

$$\text{Per cent } FeCl_3 = K \frac{\text{Per cent Volatile}}{\text{Per cent Ash}}$$

The total ferric chloride demand is, then,

$$\text{Per cent } FeCl_3 = 1.08 \text{ per cent alkalinity of solids plus } K \frac{\text{Per cent Volatile}}{\text{Per cent Ash}}$$

The value of K derived from the selected data was 1.6. The value probably varies from the value of the first constant, 1.08, to about twice that figure. Values below 1.6 may be demonstrated to be representative of partial or incomplete ferric chloride dosing of heavy sludges of low alkalinity.

Results from many laboratory tests were used to check the equation. The calculated dose in some of these was found to be somewhat less than the recorded optimum, indicating a somewhat higher constant than 1.6. In all cases the calculated doses fell on the recorded graphs, indicating near optimum dosages for laboratory testing and reasonable low dosings for actual field practice. Comparisons of com-

puted doses for digested and elutriated digested sludges at the Cranston, R. I., plant are shown in the following table.

Description	Elutriated	Digested
Alkalinity, p.p.m.	300	2,700
Per cent volatile	57	58
Per cent ash	43	42
Per cent $FeCl_3$, computed		
Alkalinity (1.08 times percentage of alkalinity on sludge solids)	1.3	11.8
Solids (1.6 times ratio of volatile matter to ash)	2.1	2.2
Total, by computation	3.4	14.0
Total, recorded	3.3	13.9

Note: Water 97.6 per cent and solids 2.4 per cent in both sludges.

Reduction of the volatile-ash ratio through digestion means a corresponding reduction in ferric chloride demand, if elutriation is provided to remove the alkalinity. There are less solids to be conditioned and the overall percentage reduction in ferric chloride demand is:

R = 100−1/100 times (percentage of original raw solids remaining) times (percentage of original volatile content remaining).

Using results at Springfield, Mass., in 1941 a saving of 85 per cent in ferric chloride is indicated by use of the formula with a value of 1.6 for K. The raw volatile content to the raw sludge was 73.6 per cent and the reduction of volatile matter through digestion was 69.5 per cent. The ferric chloride requirements of the raw sludge are computed to be 4.46 per cent. The requirements for the remaining 48.8 pounds of solids are 1.36 per cent or 0.66 pounds of ferric chloride.

Other coagulants that have been used extensively instead of ferric chloride include chlorinated copperas, ferric sulfate, and aluminum sulfate. These substitutes must be materially cheaper than ferric chloride to justify their use, as larger quantities must be used. They appear to be of value only on well mineralized sludges of low alkalinity.

Lime is used with ferric chloride to reduce the chemical cost per ton and is used extensively on raw and digested sludges but not on waste activated and elutriated sludges. There is a limit to the amount of lime which can be used economically. The saving realized by the use of lime depends on the ratio of the price of ferric chloride to available CaO per lb., the ratio of the two chemicals used, the minimum percentage of ferric chloride permissible with lime, and the actual ferric chloride demand of the sludge. The economic limit to which lime may be used may be expressed as follows:

$$R = \frac{L}{C - F}$$

in which R = Ratio of cost of ferric chloride to cost of lime
L = Percentage of lime on sludge solids
C = Percentage of $FeCl_3$ used alone to produce an economical filter yield
F = Minimum percentage of $FeCl_3$ used with lime to produce the same yield.

Nothing is saved when R equals the right hand member of the expression and money can be saved only when R is greater.

T. L. Herrick

Increased Efficiency from an Old Sewage Disposal Plant. By E. E. W. Oke. *Engineering Contract Record*, 58, 4, 55–57 (1945).

The original sewage treatment plant serving Cochrane, Ontario, was constructed in 1922 following a typhoid epidemic in the city. The entire plant was housed under one roof and the air for diffused aeration was taken from the inside of the building. This lowered the oxygen level within the structure and also allowed severe condensation. In the renovation of the plant air was taken from the outside of the structure with improved results. The activated sludge dried with difficulty and was, therefore, discharged into a lake downstream from the plant. This method was later changed to spraying the activated sludge on adjacent farm lands with entire success.

Other renovations at the plant include two detritus tanks and a flow meter. Average operating figures are as follows:

Aeration—10.7 hours
Air used—2.6 cu. ft. per gal.
Suspended solids, raw sewage—880 p.p.m.
Effluent—2 p.p.m.
B.O.D., raw sewage—120 p.p.m.
Effluent—16 p.p.m.

Ralph E. Fuhrman

Talco Refinery Trade-Waste Treating Purifies Water for Cooling. By C. G. Rook, Jr. *Petroleum Refiner*, **24**, 7, 271–2 (July, 1945).

Refinery waste water contains emulsified oils, sulfur compounds, caustic, ground spillage, wash water and other contaminants. It is a highly alkaline, turbid, offensive waste which is unsuitable for industrial use and may be a serious stream pollutant.

Talco Asphalt and Refining Division, Mt. Pleasant, Texas, placed a waste treatment plant in operation in January, 1945, with the dual objective of reducing stream pollution and providing a supply of clean cooling water.

All of the waste water is conveyed by a common sewer to primary and secondary oil separators where free oil is recovered and pumped to a slop tank for reprocessing. The oil-free water is treated successively with sufficient sulfuric acid to neutralize the alkalinity, break the oil-water emulsion, and adjust the pH to 7; with about 700 p.p.m. of copperas (ferrous sulfate) to precipitate sulfides and provide iron for subsequent flocculation; with enough chlorinated lime to precipitate the iron and increase the pH to 8. After each chemical addition the water passes through tubular mixers. The treated waste then passes to a sedimentation basin where the floc settles out and a clear, odor-free supernatant overflows to a storage basin. Accumulations of sludge in the settling basin are periodically withdrawn by a centrifugal pump and passed through a filter press.

The treated water is used for cooling tower makup and the excess is allowed to flow to a nearby stream. No analyses are given of either before or after treatment.

Richard D. Hoak

Current Developments in Waste Utilization. By Harold R. Murdock. *Ind. Eng. Chemistry*, **38**, 1, 85–6 (adv. section), (January, 1946).

The year 1946 will become an important milestone in the history of waste utilization and the abatement of stream pollution. The passage of federal legislation on the subject may be anticipated; practically every industrial state has prepared rigorous regulations which will greatly aid in the correction of stream contamination. Industry and municipality alike have become increasingly alert to their responsibilities, and many plants have co-operated in establishing groups to study wastes problems on a national basis.

In 1938, public sewers discharged 5.75 billion gal. of sewage per day, of which about 60 per cent had received some degree of treatment. The calculated equivalent of industrial waste, based upon the same relative sewage concentrations, is around 7.36 billion gal. per day.

The first comprehensive public sewer system in the country was designed for Chicago in 1855. In 1860, about 1,000,000 people, or 17 per cent of the urban population, was served by sewers. By 1900 these figures had increased to 25,000,000 and 35 per cent; in 1942 they were 70,900,000 and 87 per cent. In 1900, sixty treatment plants served 1,000,000 people; in 1942 there were 5,600 plants with a connected population of 42,000,000, or 60 per cent of the total connected to sewerage. The sewage from treatment plants has a residual polluting effect equivalent to the raw sewage from 18,400,000 people; adding this figure to the 28,700,000 people whose sewage receives no treatment there is obtained a total pollution load from sewage of about 47,000,000 persons.

Based upon USPHS studies of the Ohio River basin, the pollution load from industrial wastes has been estimated to have a population equivalent of 60,000,000. The economic losses resulting from the pollution of sources of water supplies are serious. A variation from low to high pollution loads has been estimated to increase the cost of water treatment from $7.90 to $16.00 per million gal. The Public Health Service estimates that the probable tangible annual damage to streams by pollution amounts to at least $100,000,000.

The estimated cost of equipment for treating the total sewage and industrial waste of the nation amounts to $2,873,320,000. This figure includes an estimate of $618,170,000 for the treatment of industrial wastes for which suitable methods are now unknown; the estimate has been made on the basis that the cost of the equipment required for processes yet undeveloped will approximate that for sewage treatment. Assuming a useful life for the plants and interest at 3 per cent, $147,000,000 would have to be set aside each year to liquidate

the investment. These figures do not include operating or maintenance charges but if we accept the estimate of more than $100,000,000 annual damage from stream pollution the investment in treatment facilities would appear to be substantially self-liquidating. This is not strictly true because of the heavy expense of enforcing abatement legislation.

It is essential that the problem be approached from a national point of view, and research is the real answer. If but a small portion of these annual charges were appropriaated to capable organizations for intensive studies directed toward profitable utilization of wastes, the projects would soon show profits rather than merely abate stream pollution.

Ind. Eng. Chemistry, **38**, 2, 83–4 (adv. section) (February, 1946).

"Nothing is more fundamental than the right of the people to have the public streams from which they draw their water supply, free from pollution." This frank statement in a decision of the Court of Common Pleas of Philadelphia County is a signal for action on a matter which has been put off too long.

Until recently most industrial plants attempted to solve their pollution problems independently, but the larger industries have now realized that the fundamental principles of waste treatment are similar for all plants in each industry. Consequently various organizations have created groups to establish the basic principles necessary for a clear approach to the problem.

In the field of inter-industry activity a number of technical associations have held symposia dealing with industrial waste treatment. State and federal health agencies have been working vigorously to insure that pollution abatement will receive proper consideration in postwar planning. Pennsylvania has been outstanding in aggressiveness by demanding not only public health protection but also that streams shall be free from discharges harmful to animal or aquatic life or to their use for recreation. Orders are being issued to those responsible for stream pollution informing them of the degree of treatment required and directing the submission of satisfactory plans for treatment works. Practically all states having concentrations of industry are proceeding along similar lines. In addition, a number of groups of states have established organizations to deal with pollution in interstate streams.

The beet sugar industry early (1906) occasioned complaints of fish killings resulting from the discharge of its waste waters. Although pulp drying equipment was installed in all beet sugar factories in Michigan in 1910, the problem was not solved until the Michigan State Planning Board, in co-operation with the Michigan State College Engineering Experiment Station, established standards of oxygen demand for such plants by erecting a 1,000,000 gal. per day experimental plant. The standards set have been substantially met and the nuisance abated.

Intra-industry activity was first exemplified by the steel industry which inaugurated a concerted attack on the problem of liquid wastes by supporting a fellowship at Mellon Institute in 1938, but the pulp and paper industries have set a model for integrated study of industrial waste. This important industry formed The National Council for Stream Improvement, Inc., Which is subscribed to by 80 per cent of the industry and has an annual budget of $150,000 to which may be added an equivalent amount. The first step was to bring together the technically qualified groups interested in stream pollution in each regional area. Seven regional committees were then created whose members were empowered to speak for their companies. The function of the committees is to assemble research and experience of individual companies on waste treatment, recovery and utilization and to make the information available to paper and pulp mills generally in order to avoid duplication of effort. Another function is to suggest research problems to the technical staff of the council for solution by the fellowships which are being established at various points in the country.

A centralized research organization was formed at Mellon Institute to serve as a contact group. Its first assignment was to review published literature and prior art on the treatment, recovery and utilization of pulp, paper and paperboard wastes with regard to modern technology and to submit reports thereon with recommendations for further study.

The council has also entered into an agreement with the Institute of Paper Chemistry to maintain a complete bibliography, and has taken over the activities of the Sulphite Pulp Manufacturers Committee on Waste Disposal of Wisconsin. An important phase of the council's activity is the study of streams and determination of the relative responsibility for pollution between the pulp and paper industry and other polluters on the watershed. A project has been established at Manhattan College to make studies of individual stream conditions under consideration by the regional committees.

The priority of regional projects supported by the council is based on four factors: concentration of particular product production, severity of the stream problems, facilities of research organizations in the region, and facilities of the regional mills for assisting in the work. The National Council has demonstrated considerable skill in coordinating the many factors which enter into the problem. The procedures used will become models for other industries.

RICHARD D. HOAK

Industrial Waste Treatment. BY MARTIN A. MILLING. *Sewage Gas*, 7, 4, 1-6 (December, 1944).

The problem of the discharge of industrial wastes into municipal sewerage is discussed and it is pointed out that industry, as a large taxpayer, does not always understand why its waste waters cannot be treated by the municipality.

Many industrial wastes interfere with sewage plant operation by inhibiting natural biological activity, by corroding equipment, or by exceeding the capacity of the plant. Usually the industrial waste load is not constant, and the resulting variability in sewage composition appreciably decreases the efficiency of treatment. Where plant operation is seriously disturbed it is often necessary to by-pass certain units until normal operation can be restored. The discharge of untreated sewage may result in lawsuits for riparian damage and the general taxpayer does not think that he should be responsible for expense of this character.

Large cities usually can offer industry more than small ones in the way of labor supply, services, etc., and, except in uncommon cases, the sewage-industrial waste ratio is such that manufacturing waste can be handled by the municipal sewage plant. If small cities want to encourage industrial expansion they must have something to offer, but this does not mean that ordinances which regulate the discharge of wastes should be abandoned. It does mean that local laws should be flexible and intelligently enforced.

Sewage treatment plants should be designed with a view to handling all sewage and industrial waste originating in the community, wherever this is economically possible, so that treatment costs may be equitably distributed. Where pretreatment of industrial wastes is necessary, proper approach to the industry in question will usually result in the co-operation desired because the average manufacturer is civic-minded and able to appreciate the circumstances which require him to modify waste waters before discharge.

There has recently been an acceleration of interest in the recovery of by-products from industrial wastes and a number of industries have found recovery profitable. Such progress as has been made in this direction, however, can be regarded only as a beginning, but, as newer processes are developed for treating wastes, the problem of stream pollution abatement will become less complex and gross pollution will no longer be tolerated.

RICHARD D. HOAK

Three Industrial Waste Problems at Marion, Indiana. BY DAVID P. BACKMEYER. *Sewage Gas*, 7, 4, 7-10 (December, 1944).

The activated sludge plant operator noticed a white industrial waste entering the plant at 3 A.M. which persisted until 8 A.M. At 9 A.M. the B.O.D. of the primary tank effluent exceeded 355 p.p.m., by 2 P.M. the final settling tanks were foggy, and the next morning the final effluent had a D.O. of less than 1 p.p.m. Within 72 hours the sludge index increased from a working average of 70 to 140. It took 27 days to restore a normal activated sludge. Inquiry showed that the condition arose from the discharge of 5,000 gal. of condensed milk from a cannery.

Occasional difficulty has occurred from

the discharge of fuel oil from two manufacturing plants. A large percentage of the oil can be removed by skimming but several times it has been necessary to bypass some of the primary effluent to protect the aeration units. Pumping the oil to the digesters is unsatisfactory because it does not digest, and when supernatant is withdrawn the oil returns to the primary tanks and must be handled again. Wherever possible the oil is removed from the grease well and burned.

Discharge of small quantities of sodium silicate from a boxboard plant has seriously clogged sewer lines. The silicate gradually crystallizes in the sewer until the normal sewage flow can no longer be handled. Slabs of silicate 6 inches thick and several feet long have been removed when it became necessary to clean a sewer section a city block in length.

RICHARD D. HOAK

Sodium Cyanide Waste Kills Fish in White River. By R. R. BAXTER. *Sewage Gas*, 7, 4, 11–13 (December, 1944).

The author observes that industrial toxins may sometimes be passing through a sewage plant undetected by routine analyses, and cites a fish-killing as an illustration.

Dead fish were reported at a point 16 miles downstream from the sewage plant. The cause of death was diagnosed as cyanide poisoning and investigation disclosed that the plant effluent contained 3.9 p.p.m. of sodium cyanide at the time of the killing. A survey of local industry revealed that a number of plants were using large quantities of sodium cyanide. Discussion of the problem with the managers of these plants resulted in the adoption of measures to prevent a recurrence of this dangerous discharge.

RICHARD D. HOAK

Woolen Mill Waste at LaPorte Sewage Treatment Plant. By JOHN E. HUPP. *Sewage Gas*, 7, 4, 14–15 (December, 1944).

The sewage works receives from 200,000 to 750,000 gal. of waste water from a woolen mill and this flow sometimes amounts to 20 per cent of the load on the plant. The waste consists mainly of wool scouring, lime softener, and dye waste.

Most of the operating difficulty was caused by fibers, which clogged sludge lines and matted in the primary tanks. The fibers caused pooling of the trickling filters and plugged spray nozzles so quickly that they had to be cleaned daily. They formed a scum in the digester which had to be removed by hand, and some were even carried through the gas dome and into the gas meter.

After three years of negotiation the woolen mill officials agreed to install a 40 mesh screen, which eliminated most of the difficulty. Two years were required to remove all of the wool from the trickling filter.

RICHARD D. HOAK

Cannery Waste Problems at the Peru, Indiana, Sewage Treatment Plant. By IREL V. PENCE. *Sewage Gas*, 7, 4, 16–18 (December, 1944).

The major industrial waste load on the treatment plant comes from a cannery where peas, corn, peaches, lima beans, vegetarian beans, and sauerkraut are processed.

The cannery maintains a mechanical screen but it does not always operate efficiently and considerable quantities of various solids flow to the sewer. Bar screens and grit washers at the sewage plant have to be cleaned quite frequently.

The B.O.D. of this waste varied from 400 to 800 p.p.m. The sewage plant was continually overloaded and bulking in the secondary tanks was a serious problem. Usually 75 lbs. of chlorine per day was sufficient to retard bulking but it was never completely eliminated.

Suspended solids increased greatly during the canning season and the digester could not handle the extra load. Incomplete sludge digestion resulted which yielded a poor supernatant. Gas production, however, increased about 40 per cent and permitted the use of the gas engine throughout the canning season; the estimated saving in plant operation was $1,500.

Digester gas contained between 200 and 400 grains of hydrogen sulfide per 100 cu. ft. Complaints from nearby residents necessitated substitution of a dry for a wet gas scrubber to keep hydrogen sulfide at a satisfactory concentration level.

RICHARD D. HOAK

Industrial Waste Problems at Muncie Sewage Plant. By PAUL W. WHITE. *Sewage Gas*, 7, 4, 19–22 (December, 1944).

Muncie is a city of diversified industry and while some trouble from industrial waste is to be anticipated, with a few exceptions the wastes respond readily to standard treatment.

Pickling liquor from a steel company upset plant operation for a time, but investigation showed that the liquor was reaching the sewer from a break in a company sewer. When the break was repaired, the trouble disappeared.

Oil and grease have always been the most troublesome waste and repeated surveys have failed to eliminate enough of these discharges at their source to relieve the difficulty at the plant. Oil and grease skimmings are pumped to the digesters where they separate on the surface and prevent withdrawing a satisfactory supernatant. Digestion and gas production do not seem to be hindered by the oil. Sludge which contains an excessive amount of oil dries poorly and cannot be used as fertilizer. Biological oxidation is sometimes impeded by these wastes.

Seasonal operation of two tomato canneries have caused trouble by clogging the primary sludge pump and increasing the amount of primary tank skimmings, but difficulty from this source is insufficient to affect plant efficiency. Another cannery operates its own activated sludge plant where the B.O.D. of the waste, which approximates 760 p.p.m., is reduced 60 per cent. The effluent is discharged to a municipal interceptor and peak flows usually coincide with peak domestic sewage flows.

Necessity for enlarging the treatment plant having appeared, Muncie plans to increase the primary sedimentation capacity, install mechanical skimmers, improve the effectiveness of the aeration units, and increase digestion capacity and sludge handling facilities.

RICHARD D. HOAK

A Couple of Industrial Waste Problems at Fort Wayne. By PAUL L. BRUNNER. *Sewage Gas*, 7, 4, 23–24 (December, 1944).

Chicken feathers have caused a vexing maintenance problem. A local plant kills an average to 5,000 chickens a day over the summer months. The bulk of the feathers are recovered but some find their way into the sewage plant. The tail feathers pick up grease and plug up the scum line; sewer rods must be used about once a week. The fine feathers usually float over the effluent weirs and collect in the final settling tanks. The company has promised to correct the trouble by keeping its floor drain screens in place.

Three heavy concentrations of chromic acid reached the plant in the winter of 1942–43, the amount of chromium reaching 3,600 p.p.m. in the sewage, and the pH falling to 2.3. Failure to by-pass the waste resulted in the complete destruction of the activated sludge organisms. When the waste was traced to its source, a war industry, officials immediately took steps to handle the waste at their plant.

RICHARD D. HOAK

Industrial Waste problems at Richmond Sewage Treatment Works. By W. E. ROSS. *Sewage Gas*, 7, 4, 25–27 (December, 1944).

This plant has had occasional difficulty with packinghouse wastes and fuel oil, but its most serious problem is plating wastes.

Wastes from a chromium plating establishment introduce a fairly constant concentration of 1 p.p.m. of chromium in the sewage at the treatment works. Quite a study has been made of the effects of chromium on the activated sludge process but no definite conclusions have been reached regarding the loading of chromium which can be handled by the plant. To date, up to 1 p.p.m. has been processed without serious difficulty except for discoloration of the final effluent. It appears that hexavalent chromium is very toxic and it must be reduced to the trivalent state to render it harmless.

It has been the policy of the sewage plant to attempt to secure the co-operation of local industry without invoking the city sewer ordinance, and every industry has been willing to assist in correcting difficulties arising from their wastes.

RICHARD D. HOAK

Indianapolis Industrial Waste. By D. O. BENDER. *Sewage Gas*, 7, 4, 28–31 (December, 1944).

For many years the waste from the Indianapolis gas plant was not allowed in

the municipal sewerage because it was thought to be detrimental to the activated sludge process. When many complaints were received concerning the condition of the stream to which the waste was discharged a study of its effect on the sewage plant was made.

Enough of the waste was added to a sample of sewage to produce a concentration ten times as great as would result if all of the gas plant waste were treated with the sewage. The sample was mixed with activated sludge and aerated in a Biometer. No decrease in the activity of the sludge was noted and the waste was cut into the plant with the understanding that it could not be accepted if plant operation were seriously affected. For several years no difficulties attributable to this waste were experienced; then an excessive quantity of phenol began to appear at the plant. It was found that the preliminary treatment at the gas works was operating inefficiently. During the three months this condition existed, however, the sewage plant operated, in some ways, better than before.

The data collected indicated that the gas works waste was very advantageous to the activated sludge process. It probably was responsible for the high rate of treatment possible while the waste was being received, but there is no positive proof of this. The waste has one bad characteristic. It contains a tarry material which collected on the diffuser plates and is believed to have done some damage.

RICHARD D. HOAK

National Stream Pollution Control Activities. By W. H. WISELY. *Sewage Works*, **8**, 3, 3–12 (September, 1945).

More than $1,250,000,000 worth of construction is already planned for the elimination of existing stream pollution. The following factors are responsible for this backlog of public works: (1) the acceleration in construction of pollution abatement works which derived from the depression of the 1930's, interrupted by the onset of war in 1941; (2) the activities of state and federal pollution control authorities whereby individual sources of pollution have been located, evaluated and brought to the attention of those responsible; (3) the interest in pollution control legislation, both state and national, which has heretofore been sorely needed for the guidance of abatement programs; (4) the well conceived and executed postwar planning campaign of the Committee on Water and Sewage Works Development, which has spread the gospel of "municipal hygiene" to every corner of the nation; and (5) the fact that sewage works technicians have gained the confidence of the public for their ability to provide efficient and economical treatment.

In the conduct of pollution abatement campaigns among the various states it is significant that an effort is being made to secure voluntary abatement without recourse to the enforcement provisions of the law. States are founding their programs on sane and practical evaluations of stream usage, then proceeding to sell municipal officials and the public on the merits of clean streams and community responsibility.

State officials have been farsighted in maintaining short course schools for training sewage plant operators, in spite of the war, and recognition of competent operators, through registration or certification, has been pertinent to the objective of improving the quality of treatment plant personnel.

The Congress has shown an eagerness to consider pollution control on a national scale, as evidenced by the introduction of no less than six bills. It is fitting that the Congress should recognize the general problem, and that provision be made for a national agency to guide, coordinate and support the heterogeneous activities of the various states.

As a result of the intense activity of the "Blueprint Now" committee, every conscientious municipal official, engineer, or sewage works superintendant will, by this time, have reviewed the needs of his community and given some thought to means for satisfying those needs. The general improvement in municipal finances since 1941 will make it difficult for a council to justify the claim that it cannot afford sewage treatment. It is the consensus of the soundest minds that sewage works planning should proceed without dependence on federal financial aid and that the merits of stream sanitation justify their cost. Where there is a deterioration of the national economy which would warrant pub-

lic works, however, sewage and waste treatment works should receive first consideration.

Progress which has been made in the abatement of industrial pollution has not kept pace with sewage treatment, and while the reluctance of industry to incur the cost of treatment is understandable, the responsibility exists and industry has come to recognize it. The lead in fundamental research on waste treatment has been taken by a number of industrial trade associations which are sponsoring serious research programs. Great accomplishments are imminent in this difficult field as a result of these studies.

The need for stream pollution abatement has been recognized and the challenge accepted. A foundation for intelligent control is being laid, and sound and careful planning has been made the keynote of the forthcoming abatement program.

RICHARD D. HOAK

Cannery Waste Treatment. By ROBERT W. HEIDER. *Sewage Gas*, 8, 3, 28-34 (September, 1945).

About 17,000,000 cases of canned goods are packed annually in Indiana, which ranks second in the Nation in cannery product. Sixty per cent of the pack consists of tomatoes; other major products are: corn, peas, beans, beets, mixed vegetables, and pumpkin.

Canneries use large volumes of water which pick up a heavy organic load (up to ten times the equivalent of domestic sewage) and present a difficult treatment problem because maximum production occurs during the months when stream flows are normally lowest.

It is fundamental that canneries should pass their wastes through fine screens; such an operation has been shown to effect a marked reduction in the organic load passing to municipal or company sewers. General good plant housekeeping also results in a significant reduction in the waste which must be disposed.

Cannery wastes can be treated successfully with domestic sewage at biological filtration and activated sludge plants where the ratio of the wastes to the sewage is not too high and the sewage works has adequate capacity. Eldridge states that where cannery wastes represent more than 25 per cent of the combined volume, or more than 50 per cent of the combined B.O.D., it should be treated separately or pretreated before discharge to the municipal sewers. Where a sewage plant is overloaded a satisfactory effluent can be obtained by providing either:

1. Additional pre-treatment at the cannery. Screening, or possibly vacuum flotation, plus one or a combination of the following:
   a. Chemical precipitation
   b. Biological filtration
   c. Discharge into an impounding lagoon or reservoir to regulate the flow to the sewage works
   d. pH adjustment
   e. Disposal of part of the waste by lagooning or irrigation
2. Additional treatment at the sewage works. An increase in the size of various treatment units and or one or a combination of the following:
   a. Use of chemicals and mixing and coagulating equipment to increase primary settling efficiency
   b. Pre-aeration. Plain aeration of the combined waste prior to either biological filtration or activated sludge
   c. Recirculation of the final effluent
   d. Conversion of standard secondary treatment to multiple stage secondary treatment, *e.g.*, use of a roughing filter before the biological filter or activated sludge units
3. Combination of (1) and (2)

The location of a cannery, its seasonality, and the character of its receiving stream will govern the type of separate treatment adopted. Screening should be provided regardless of the treatment selected. The following methods have been used successfully:

1. Chemical precipitation
2. Chemical precipitation plus biological filtration
3. Absorption lagoons
4. Irrigation fields
5. Impounding lagoons (untreated)

6. Impounding lagoons (sodium nitrate treated)

Lagoons have often been used by canneries in rural areas where available streams provided inadequate dilution but these have been the source of frequent complaint because of "accidental" discharge, and odor or mosquito nuisances. The latter can be easily abated by larviciding. Lagooning of screened wastes is entirely practicable where proper control is exercised. Where enough sodium nitrate is added to satisfy 20 per cent of the initial B.O.D., odor nuisances are practically eliminated. This amounts to about 200 lbs. per 1,000 cases of vegetables.

The prospects for economical utilization of screened liquid wastes does not appear promising at present, but screenings could yield large quantities of usable by-products. Canners have been reluctant to process wastes because of seasonality, assumption of additional responsibilities during a short, busy season, and the comparatively small financial return.

The development of co-operative treatment plants serving a number of neighboring canneries, where other agricultural products might be processed as well, offers a possible solution to the problem.

RICHARD D. HOAK

Authority of the Indiana Stream Pollution Control Board to Order Ohio River Pollution Abatement. *Sewage Gas*, 8, 3, 35–38 (September, 1945).

The Indiana Stream Pollution Control Board requested an opinion of the State Attorney General concerning the authority of the Board to order the City of Evansville to cease polluting the Ohio River.

The Attorney General cited various sections of the Acts of 1943, the Virginia Compact consenting to the creation of the state of Kentucky, and a number of legal decisions. He concluded as follows: "It is, therefore, my opinion that the powers of the stream pollution board extend to the pollution of the Ohio River equally and to the full extent as to the pollution of any other streams or waters which lie within the territorial boundaries of Indiana, and that your question must be answered in the affirmative."

RICHARD D. HOAK

Stream Pollution in Oil Fields Lessened by Salt Water Disposal Systems. *Pipe Progress*, 9–11 (Dec., 1944).

Disposal of salt water in the oil fields has been a troublesome problem for a number of years. In the East Texas fields it was realized that disposal of salt water into streams would produce a serious stream pollution problem, and would in time curtail oil production through high withdrawls of fluid from the oil bearing sands. A group of East Texas operators experimented on the return of water through an abandoned oil well and later formed the East Texas Salt Water Disposal Company. The company operates 30 wells out of a total of 66 in the field. The other 36 are operated by various oil companies.

Water from the various leases is collected at a central treating plant. Oil is removed in skimming basins, after which iron is removed by aeration, alum treatment and sedimentation. Lime is used to control pH. After sedimentation the water is filtered in pressure sand filters and injected into the disposal well. Where high pressures are required, cement lined pipe has been found most satisfactory.

T. L. HERRICK

Stream Pollution in the Patoka River Basin. By ROBERT W. HEIDER. *Monthly Bulletin, Indiana State Board of Health*, 48, 9, 215–216 (September, 1945).

The Patoka River basin is located in the southwestern section of Indiana. Its area is approximately 825 sq. mi. There are 12 cities and towns with populations above 300 in the basin. The total population of the 12 cities and towns is 17,448. Only 2700 or 15 per cent of this total are served by complete sewage treatment. Five of the six public water supplies in the basin use surface water.

The river is seriously polluted by coal mine drainage and oil field brine.

Because of the pollution of the river, one city was forced to abandon the stream as a source of municipal water supply.

Municipalities and industry should begin an intensive pollution abatement program.

PAUL D. HANEY

A CORRECTION

Attention is directed to an error in the abstract of the paper "Effect of Spent Gas Liquor on Cold Sludge Digestion," as published on page 857 of the July, 1945, issue of THIS JOURNAL. In the sentence "Ascot District Gas and Electric Co. shall pay the District Council 25 s. 6 d. ($5.10) per 1,000 gal. of liquor discharged to the sewerage" the amount of the charge should have been stated as 2 s. 6 d., *i.e.*, two shillings and six pence (approx. 50 cents) per 1,000 gal.

The courtesy of Mr. Donald H. Barraclough, Manager of the Denton Urban District sewage works at Manchester, England, who is responsible for this correction, is gratefully acknowledged.

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